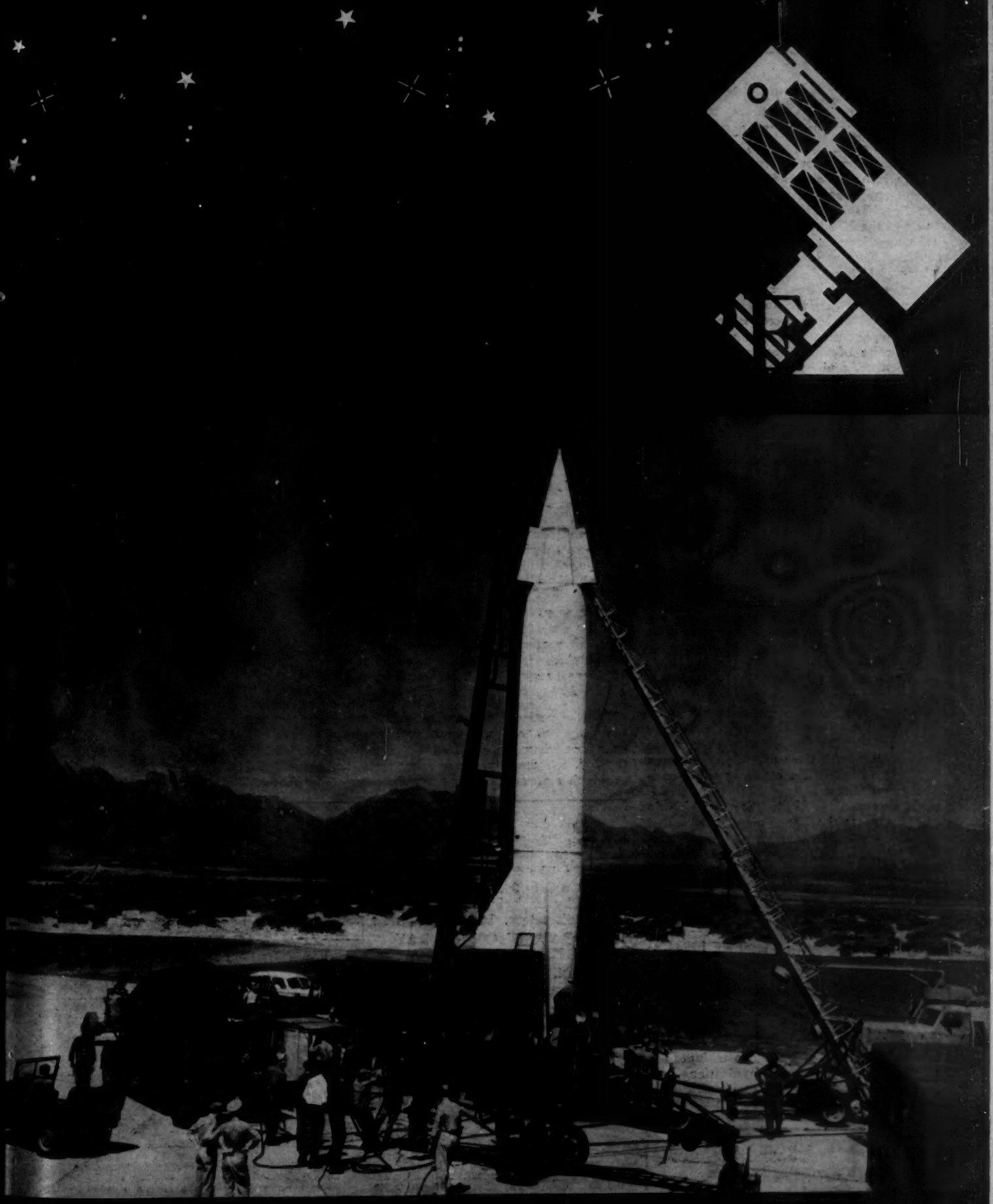

Sky and TELESCOPE

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The Editors Note . .

FOUR SUCCESSIVE MONTHS of 1948 mark conventions of the Astronomical League, an incorporated organization which now boasts 42 member societies representing some 2,500 persons. In April at New Haven was held the first convention of the Northeast region; on May 15th the now-forming region of states in the middle East will meet in Pittsburgh; on June 12-13th, at Portland, Ore., the Northwest region will convene for the first time; and on the July 4th weekend all eyes will turn to Milwaukee where the national convention will take place.

In spite of the spreading activities of the league, and growing evidence of its potentialities to fulfill its aims, there are many small and several large astronomical groups which have not availed themselves of membership. Some have felt that the membership-at-large provision is not in keeping with other league purposes, but the present six members-at-large can hardly be said to be sabotaging the interests of the societies. Furthermore, it has been found that many amateurs belong to more than one league member organization.

As everyone will benefit to a greater extent if participation in league affairs is broad and general, we sincerely hope every non-member organization will seriously consider or reconsider joining the league in the near future. The oft-raised question of what a society will get out of league membership is being definitely answered in many ways, particularly in the undoubted success of league conventions, at which many non-member individuals have been among the first to express extreme satisfaction with the convention programs and opportunities for enjoying astronomical associations.

Societies in the United States which do not belong to the league may be interested to note that there are already two member groups abroad, "Amigos de la Astronomia," Buenos Aires, Argentina, and the Aruba Astronomers Club, Netherlands West Indies.

Of current importance is the organizing of regions still unformed. Member societies in these areas are strongly urged to proceed immediately with this problem, so their regions may have specific representation on the national council at the Milwaukee convention. The executive secretary of the league is James B. Rothschild, Astronomical League, Science Service Bldg., 1719 N St. N. W., Washington 6, D. C., to whom all communications concerning membership and the formation of regions should be sent.

Indexes and Bound Volumes

All volumes of Sky and Telescope are fully indexed, and the indexes are available at 35 cents each postpaid. Send 35 cents in stamps or coin or include with your renewal check or money order. Bound volumes, at $6.50 each postpaid, are also now ready for Volumes II, IV, V, and VI.

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LEAGUE CONVENTION PLANS

As announced with preliminary plans in the April issue, further information concerning the regional convention of the Astronomical League in Pittsburgh May 14-16th may be obtained from Charles H. LeRoy, R. D. 2, Pittsburgh 15, Pa. Guest speaker at this convention will be Dr. N. E. Wagman, director of Allegheny Observatory.

The **Observer**, published by the Yakima Amateur Astronomers, announces that Dr. R. M. Petrie, assistant director of the Dominion Astrophysical Observatory at Victoria, B. C., will be the principal speaker at the first annual convention of the Northwest region of the league. The convention will be held in Portland, Ore., June 12-13th. Another guest at this gathering will be Dr. C. M. Huffer, of Washburn Observatory, who is chairman of the North Central region of the league. Further information on this convention may be obtained from the chairman of the Northwest region, T. P. Maher, Vendome Hotel, Arlington, Ore.

For the national convention in Milwaukee, July 3rd to 5th, a tentative program calls for registration at 9:00 a.m., Saturday, the 3rd, followed by the opening session, at which reports of delegates will be presented. A session for papers is scheduled for the afternoon, when there will also be a business meeting. At 5:30 p.m., buses will leave for the Milwaukee Astronomical Society Observatory, where convention delegates will have a picnic supper and an evening of observing.

Sunday morning the program resumes with a general session, and the group photograph. The banquet is at 1:00 p.m. In the afternoon, there will be movies, committee meetings, and a business meeting. After supper, a trip will be made to Yerkes Observatory at Williams Bay, Wis., home of the world's largest refracting telescope. The final session on Monday morning is to be devoted to elections, reports, resolutions, and the like, after which the convention will be adjourned.

The convention is to be held at Concordia College, which is located at 3126 West Kilborn Ave., Milwaukee. Meals and lodging will be provided by the college at five dollars per day per person. A limited number of persons can be accommodated on Friday night, but in general rooms will not be available until Saturday. Further information can be had from the convention chairman and president of the Milwaukee Astronomical Society, Ross Bardell, University of Wisconsin Extension Division, 6th and State Sts., Milwaukee 3, Wis.

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WHOLE NUMBER 79

MAY, 1948

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BACK COVER: A drawing by Russell W. Porter of the prime-focus cage of the 200-inch telescope. Courtesy, California Institute of Technology. (See In Focus.)

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Exploratory Cosmic Ray Observations at High Altitudes by Means of Rockets*

By J. A. Van Allen, *Applied Physics Laboratory, Johns Hopkins University*

MOST COSMIC RAY investigations have been conducted in laboratories at various altitudes on the surface of the earth. Yet the broadest perspective on the subject has been acquired from observations high in the atmosphere with equipment carried by balloons, in particular, and by aircraft. During the recent war, rockets were brought at last to such a state of development as to become suitable vehicles for the transport of experimental equipment to levels of the atmosphere previously inaccessible.

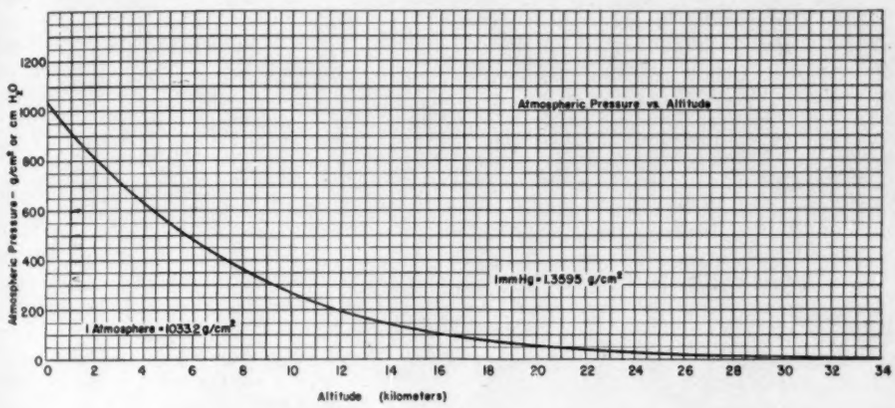

Fig. 1. Plot of average atmospheric pressure as a function of altitude above sea level.

The earth's atmosphere is reasonably transparent to visible light, to sound waves, to a wide range of radio waves. Yet to the cosmic radiation it has been found that the atmosphere is quite opaque — the effects remaining at sea level are indeed a very remote indication of the nature of the radiation which originally strikes the atmosphere.

There can be little doubt that the very high-energy nuclear and electromagnetic processes, induced in the upper atmosphere by cosmic rays, comprise a rich range of new physical phenomena. There is, for example, the mystery of how mesotrons are produced in the air; no artificial laboratory generator of high-energy particles has yet created any such nuclear reaction.[1] Most physicists believe that the heavy mesotron is the basis for the strong cohesive forces between nuclei at close range.

Even quite rudimentary questions about the primary cosmic rays are still unanswered. It is reasonably certain that the primary rays carry an electric charge,[2] but it has not been established with certainty whether this charge is positive or negative; and it may be that there is a mixture of positive and negative rays.[3]

The preponderance of data at present indicates that most primaries produce nuclear-type reactions, as would heavy particles (such as protons), rather than electromagnetic-type reactions, as would positive or negative electrons.[4] But at first it was generally believed that cosmic rays had the nature of extra-hard gamma radiation; then later, and in fact up to about six years ago, there seemed to be good reasons to think that they were electronic in nature.

Many experiments, some of them quite simple in conception, remain to be done before a clear understanding of cosmic ray phenomena will exist.

The Role of Rockets

In cosmic ray work, it is common to state atmospheric pressure at any point in terms of the readings of an imaginary water barometer at that point — that is, in centimeters of water. An alternative is to state in grams the amount of material overhead in a vertical column one square centimeter in horizontal cross section — read as grams per square centimeter. In Fig. 1 is shown a plot of atmospheric pressure against altitude. From this graph it is seen that the pressure is about 10 grams per square centimeter at 30 kilometers, a typical peak balloon altitude.

Apparently good theoretical arguments give rise to the feeling that there is very little reason to carry cosmic ray equipment above this level. Otherwise stated, the theory of high-energy electromagnetic and nuclear processes indicates that there should be only trivial modification of any reasonable type of primary radiation in passage through so small an amount of matter. It is, therefore, quite natural to inquire why high-altitude rockets are of any utility whatever as vehicles for cosmic ray equipment. This question is especially appropriate when it is realized that rockets of the type at present available are quite expensive; and, furthermore, in a particular

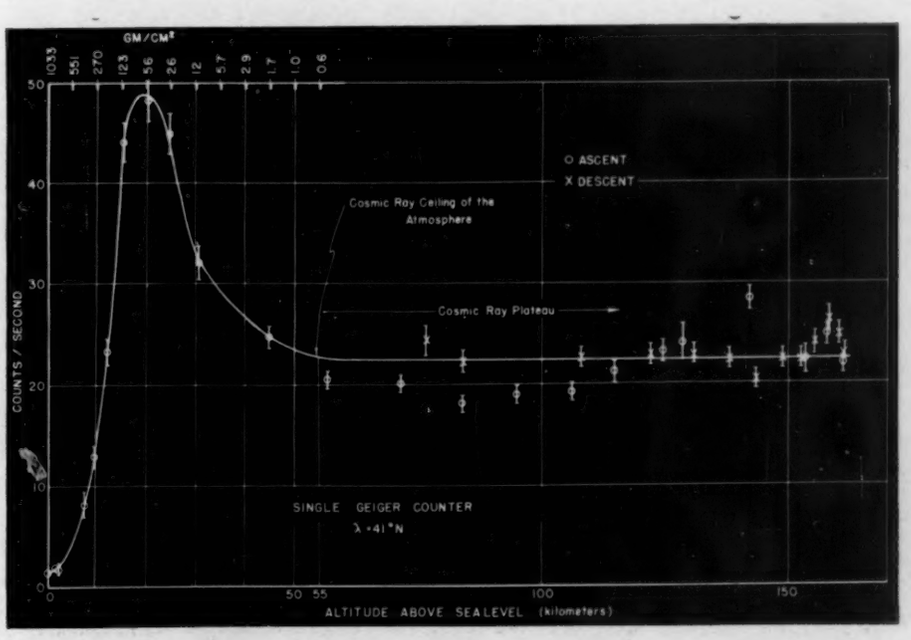

Fig. 2. The counting rate of a single Geiger counter as a function of altitude. The counter had a cylindrical active volume 15 centimeters in length and 2.38 centimeters in diameter. Note the cosmic ray ceiling and plateau.

*Supported by the Navy Bureau of Ordnance under contract NOrd 7386.

flight they spend only a brief five minutes above 30 kilometers.

Three independent groups of investigators — at Princeton University, at the Naval Research Laboratory, and at the Applied Physics Laboratory of Johns Hopkins University — have felt it worthwhile, however, to make exploratory cosmic ray observations in rockets. As bases for this belief may be listed the following:

1. The effects at an altitude of, say, 30 kilometers are due not only to radiation which has passed through 10 grams per square centimeter of material in a vertically downward direction but also to radiation which originally entered the atmosphere at zenith angles from 0° to 90°. (Aside from upward-directed secondary cosmic radiation arising within the atmosphere, the latter is very well shielded from below by the earth itself.)

Radiation arriving at a zenith angle of 75°, for example, traverses about 40 grams per square centimeter in reaching the apparatus. This situation is alleviated by directional detectors which can be pointed vertical. Yet even in this case, the assumption is made that any ray moving vertically downward at this altitude is not a secondary from radiation which arrived originally at some other zenith angle.

2. Thus far, all measurements of the asymmetry in azimuth of the total radiation at any altitude in the atmosphere up to about 25 kilometers have shown a very small asymmetry. The arguments of the section above lead us to suspect, however, that even at 25 kilometers we are not dealing with pure primaries; therefore, the asymmetry measurements may be already considerably modified by the presence of even the slight amount of atmosphere still above the equipment. This question of azimuthal asymmetry — in particular the number of rays entering from a specified zenith angle to the west relative to the number from the same zenith angle to the east — is one of the fundamental problems of the nature of the primary rays, and is of very long standing in this field.

In such experiments lies the greatest likelihood of determining the polarity of charge of the primary radiation. The opportunity to carry a suitable set of cosmic ray telescopes definitely above the appreciable atmosphere in order to make such measurements is indeed very appealing.

3. Another basic quantity is the number of rays striking the atmosphere per square centimeter per second. This has up to recently been determined only indirectly from the integration of the amount of ionization in a column of atmosphere of unit cross section. Several assumptions of doubtful validity are involved in interpreting such results to yield primary flux. Rockets provide a potential opportunity for direct measurements of the flux of particles at an altitude sufficiently great to be considered free of secondary multiplications.

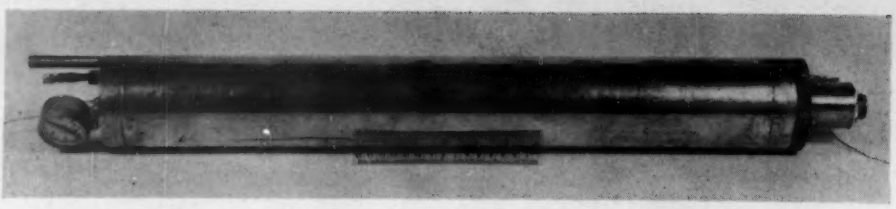

Fig. 3. A brass-walled ionization chamber, filled with purified argon to five atmospheres pressure. For calibration in flight, a sealed-in steel rod is moved magnetically to expose a thin polonium source.

4. The detailed nature of the "primary act," in which a primary particle makes its first encounter with material, is the subject of foremost interest both theoretically and practically in very high-energy nuclear physics and electromagnetics. In spite of the reasonably high altitudes achieved with balloons, there is still a remaining doubt that we are actually dealing with the primaries themselves.

5. Arrays of equipment involving massive absorbers cannot at present be lifted above about 14 kilometers by any other means than rockets. For this reason alone, rockets have a valuable function; the V-2, for example, can carry about 1,000 kilograms of experimental equipment.

6. Finally and most importantly, no experimentalist has such an implicit faith in the completeness of current theories as to fail to take advantage of any opportunity to extend the realm of actual observations, even though only in an exploratory way. Cosmic ray studies in the past have yielded pioneer information on very high-energy nuclear and electromagnetic processes. It is not unlikely that further understanding of high-energy particle physics will come first in the study of cosmic rays.

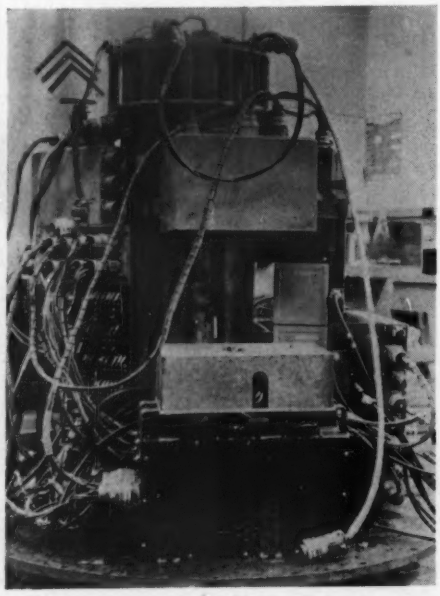

Fig. 4. An array of four ionization chambers (long tubes in central part of picture) with associated electronic equipment mounted on the base plate of a V-2 warhead. This equipment operated successfully in missile No. 30, fired at White Sands, July 29, 1947.

Results in the Past Two Years

The investigators of Princeton University had a series of very unfortunate rocket flights and have for this and other reasons been forced to withdraw from rocket research without having obtained flight results. Preliminary reports of the Naval Research Laboratory have been published elsewhere.[5] The remainder of this article, therefore, represents a resume of some reasonably clean-cut and definite results obtained by the Johns Hopkins group in a series of V-2 flights beginning on April 19, 1946. The front cover shows the fueling of the flight of July 30, 1946.

The Cosmic Ray Ceiling

In a V-2 flight in July, 1947, a single Geiger counter in a physical arrangement especially worked out to free it from the extraneous effects of surrounding material yielded an excellent set of data. The altitude plot of the observed counting rate of this single counter is shown as Fig. 2. In addition to having traced out, by its counting rate, the well-known Regener-Pfotzer-Millikan maximum of intensity at about 19 kilometers altitude, it demonstrates for the first time the experimental cosmic ray ceiling of the atmosphere.[6] By this term is meant the altitude above which there is no appreciable effect of the atmosphere on the primary radiation. This altitude may be read from Fig. 2 as being about 55 kilometers. It appears fair so to interpret this result because a single counter is perhaps the most sensitive instrument for determining the occurrence of secondary effects — either attenuation or multiplication.

The Cosmic Ray Plateau and the Absolute Number of Primaries Striking the Earth

The region above 55 kilometers is known as the cosmic ray plateau, in which there is no further change in cosmic ray intensity. Since there is no change in the counting rate of a counter between 55 and 161 kilometers, it is very *tempting* indeed to conclude that we are dealing only with the primary radiation in this region and to conclude further that this plateau value of count-

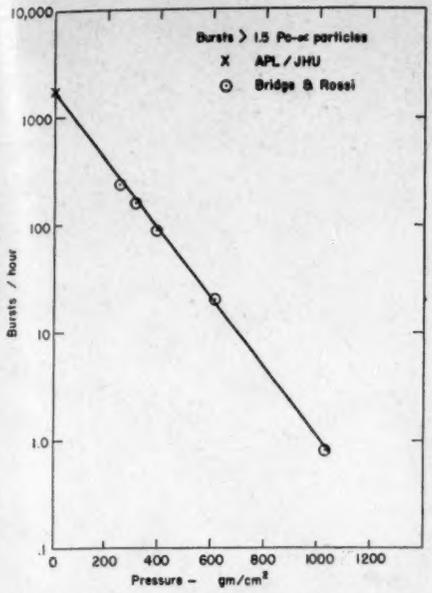

Fig. 5. A composite plot of time-rate of large bursts of ionization versus atmospheric-pressure altitude. The bursts were greater than 1.5 times a polonium alpha particle (greater than about eight million electron volts).

ing rate would continue for many hundreds of kilometers higher. It would be expected that the plateau value of the counting rate at either magnetic pole of the earth would be the same as observed at any point in free space within the galaxy, at least. However, at all lower magnetic latitudes, the original free-space intensity is believed weakened by deflection away from the earth of the lower-energy charged primaries. Therefore, one may expect the counting rate to rise at distances from the earth of the order of the earth's radius and to approach asymptotically the value observed over the magnetic poles.

This is almost certainly the correct general picture; but it is not yet adequately clear to what extent secondaries, formed within the atmosphere and traveling upwards, may contribute to the measured intensity in this region.[5]

The counting rate observed on the plateau is the number of charged particles passing through the counter per second; from this it is easy to determine the flux of cosmic ray particles in number per square centimeter per second per unit solid angle averaged over the upper hemisphere. This number is found to be 0.12 at the latitude of 41° magnetic at which this experiment was conducted. If one accepts this experimental figure on its face value and compares it with estimates which have been made previously on the basis of the total ionization in a unit column of atmosphere, then one has an estimate of the proportion of the primary energy which disappears into non-ionizing forms. This proportion, heretofore unknown, is of great significance.

Thus, it is well known that in ordinary beta-ray emission by nuclei, both natural and artificial, there is a considerable apparent disappearance of energy. The neutrino has been proposed as the agent for this disappearance. In the spontaneous decay of a mesotron in the atmosphere, it is believed that one or more particles of the neutrino type are emitted. A marked discrepancy between our directly measured flux and the one inferred from ionization measurements is not wholly surprising and is, in fact, to be expected. Results to date indicate that over half of the original primary energy disappears into forms not detected in the atmosphere. The reader must be cautioned, however, that no thoroughly firm estimate has yet been made of the contribution to the apparent primary flux by secondaries emerging from the atmosphere. Such determinations are the subject of current work; but it already appears unlikely that the above conclusions will be modified in any essential way.

The Burst-producing Component of the Primary Radiation

During past years, there has been accumulating a great deal of evidence[2] for the extremely rapid increase with increasing altitude of the numbers of neutrons in the atmosphere, the number of so-called cosmic ray stars as observed in photographic plates, and the number

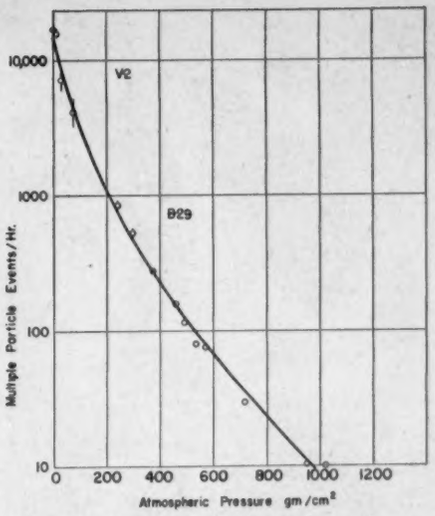

Fig. 6. Time-rate of events involving at least two ionizing particles. The observing equipment was an array of Geiger tubes amidst slabs of lead.

of bursts of ionization produced in various sorts of ionization chambers. We have undertaken to extend these measurements through and beyond the appreciable atmosphere in order to see if these various effects are of secondary or tertiary origin, or whether they are reasonably due to the primary act. Fig. 3 shows one of the ionization chambers used, and Fig. 4 pictures the complete

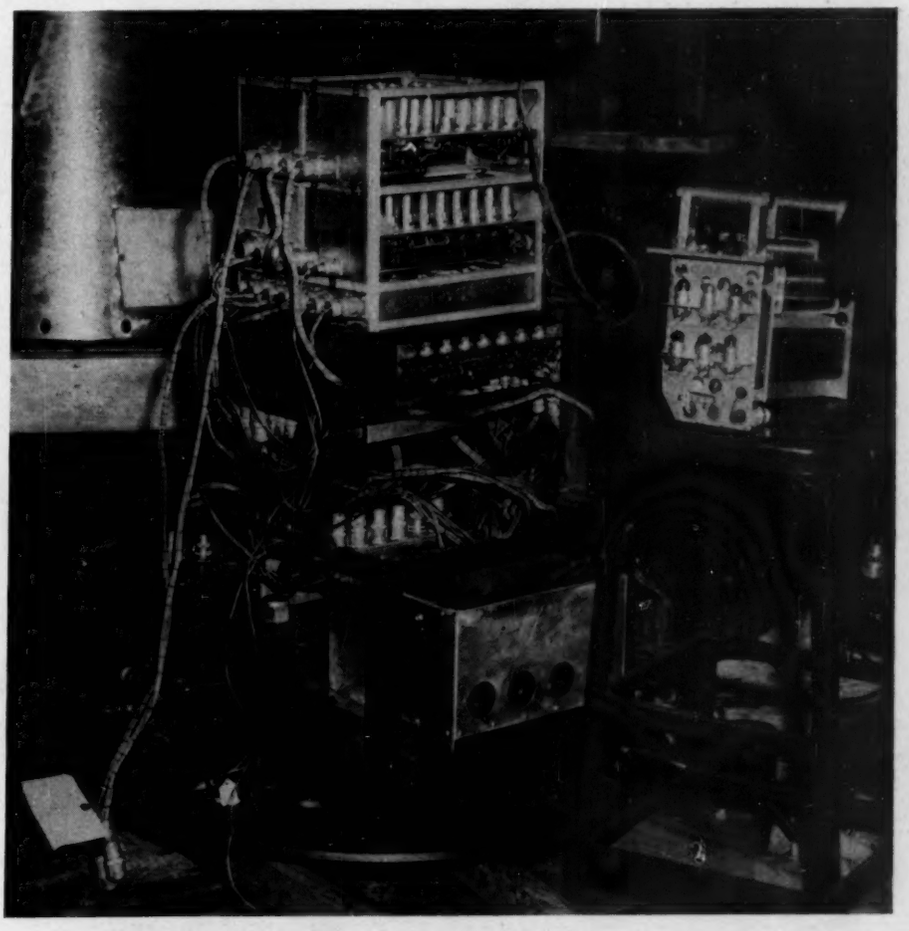

Fig. 7. Equipment after completion of laboratory testing. Note the array of Geiger tubes and lead blocks on the stool, gyros for telemetering missile aspect at lower left on the base plate, and the warhead cone in upper left.

Fig. 8. Lowering the cone into place over the equipment in Fig. 7 for shipment to White Sands Proving Ground.

arrangement under pre-flight laboratory test. In Fig. 5 is plotted a curve of certain results of the Johns Hopkins group[7] combined with corresponding results from Massachusetts Institute of Technology.[8]

The MIT results have shown the counting rate of large bursts of ionization in argon-filled ionization chambers as a function of altitude up to about 250 grams per square centimeter (about 10 kilometers). Our V-2 flights have extended these measurements to about 160 kilometers. The composite curve shows that the counting rate of bursts increases monotonically as one rises in altitude, does *not* pass through a transition maximum, and has its greatest value on the plateau above the appreciable atmosphere. It seems most reasonable to conclude that such bursts are caused by the first interaction of primary particles with matter (the primary act).

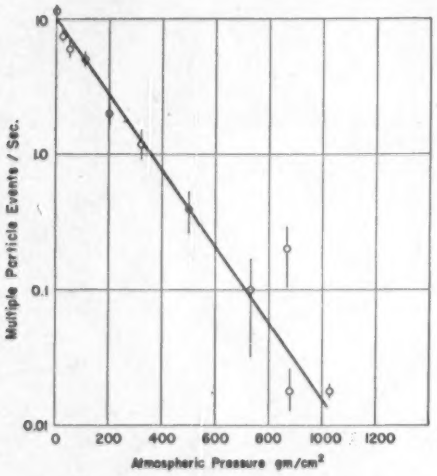

Fig. 9. Time-rate versus atmospheric-pressure altitude of events in a triangular array of Geiger tubes arranged so at least two diverging particles were required to register. Relatively little material surrounded the array.

To be sure, it may be that the detailed shape of this curve is modified to some extent by the known burst-producing character of secondaries arising from the primary act. Yet it is clear that large bursts from such secondaries do not occur in sufficient numbers to alter the principal conclusion. In Fig. 6 are shown confirmatory data from a different type of apparatus (Figs. 7 and 8) flown in a B-29 aircraft and in several V-2's. This curve exhibits the counting rate of a non-linear array of Geiger counters surrounding a block of lead. It is evident that the counting rate of such an arrangement likewise increases monotonically with altitude in a manner very similar to the burst rate in an ionization chamber. A further curve (Fig. 9) shows similar results with another non-linear arrangement of counters under rather different physical conditions.

It must be emphasized that the shapes of the curves of Figs. 5, 6, and 9 are totally different than one would expect if primaries were electromagnetic in nature. Electrons, because of their low ratio of mass to charge, exhibit mainly electromagnetic reactions with matter and should yield a prominent transition maximum of showers in the atmosphere. However, heavy nuclear particles, such as protons, may be expected to exhibit essentially exponential absorption after the fashion of that actually observed; moreover, the absorption coefficient is reasonable in actual value. Therefore, it appears most probable that the component of the primary radiation which produces the observed bursts is a nuclear-type particle.

Now it is most important to inquire whether the burst-producing primary component is a minor one or whether it is a major or total component. Comparison of the absolute rate of occurrence of bursts in an ionization chamber, shown in Fig. 3, with the total flux of primary particles through it indicates that at least a major fraction of the primary particles belong to the burst-producing species; but it is not yet possible to say whether this is the only kind of primary.

There is still the transition maximum of *total* radiation to be explained. This maximum is well known from the work of many investigators and is again clearly demonstrated in V-2 flights. Many persons have proposed that the

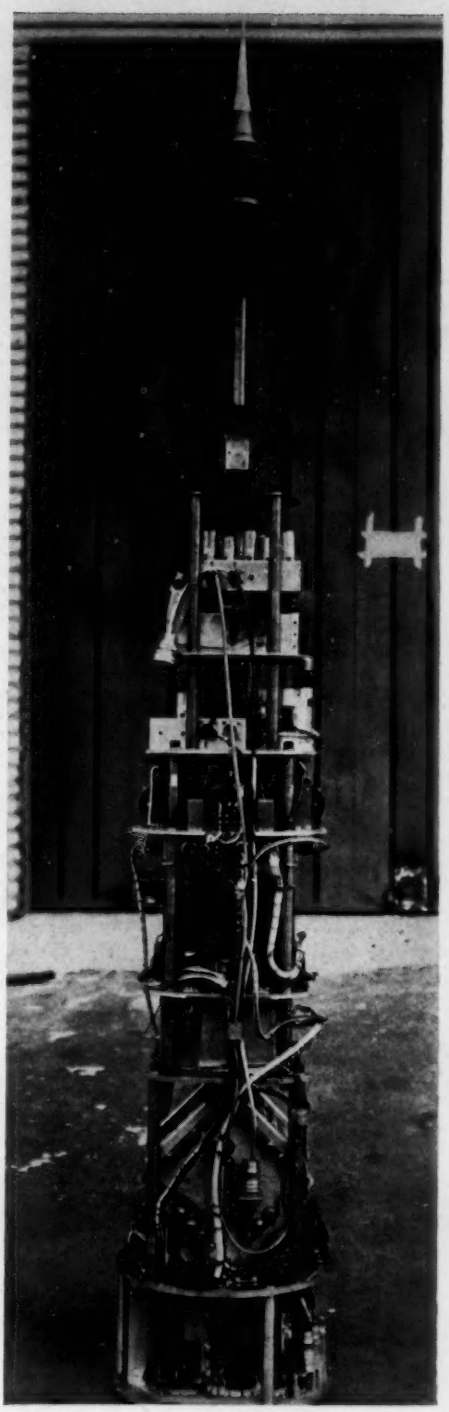

Fig. 10. Completed assembly of equipment for measuring the azimuthal asymmetry of primary cosmic rays above the atmosphere in an Aerobee rocket. Note the diamond-shaped arrangement of crossed Geiger tube telescopes near the base of the pyramid. U. S. Navy photo.

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[1]See, however, E. Gardner and C. M. G. Lattes, *Science, 107*, 270, 1948, for the first positive evidence of artificial production of mesotrons.

[2]As a general reference, the reader is referred to T. H. Johnson's translation of *Cosmic Radiation*, by W. Heisenberg, et al, Dover Publications, 1946.

[3]L. Janossy and P. Nicolson, Proc. Roy. Soc., *A192*, 99, 1947.

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[5]S. E. Golian, E. H. Krause, and G. J. Perlow, Phys. Rev., *70*, 223, 776, 1946; G. J. Perlow and J. D. Shipman, Jr., Phys. Rev., *71*, 325, 1947; S. E. Golian and E. H. Krause, Phys. Rev., *71*, 918, 1947.

[6]J. A. Van Allen and H. E. Tatel, Phys. Rev., *73*, 245, 1948.

[7]H. E. Tatel and J. A. Van Allen, Phys. Rev., *73*, 87, 1948.

[8]H. Bridge and B. Rossi, Phys. Rev., *71*, 379, 1947.

primary radiation consists of a mixture of nuclear and electromagnetic particles. The proper relative proportion of such components might provide an explanation for the effects discussed in the above sections. There are, however, other possible explanations. One of these is that secondaries arising in a primary nuclear act undergo further interactions or spontaneous decay into other particles which in turn give rise to the observed transition maximum in intensity of single particles (*not* in large bursts). No decision on this matter is yet possible.

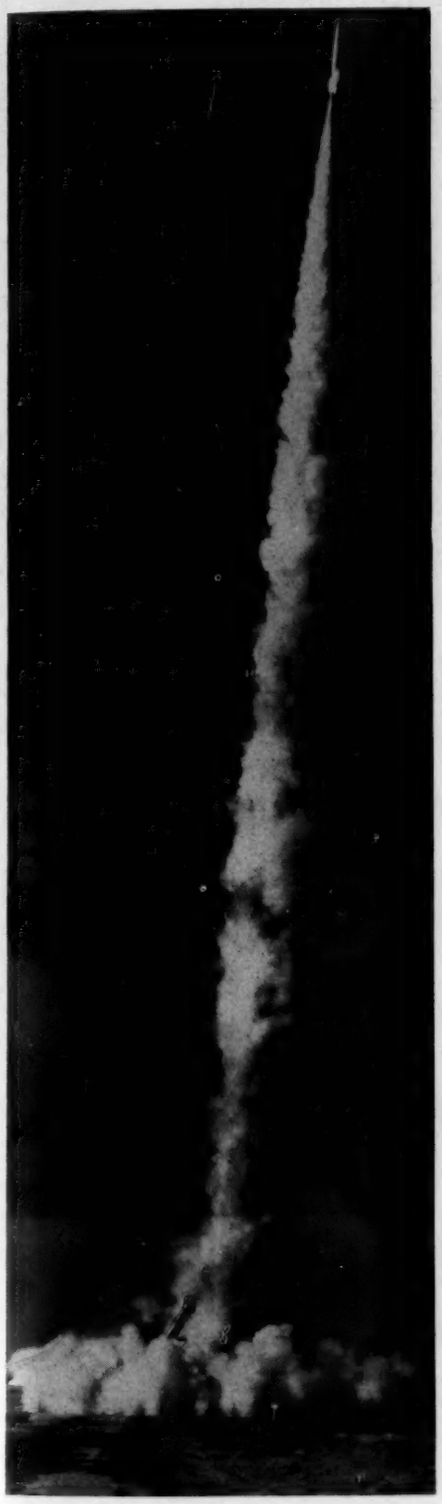


Fig. 11. The Aerobee 1.1 seconds after launching, March 5, 1948, when it set a new altitude record for American-built rockets. U. S. Navy photo.

Current and Future Work

Current work is being directed toward further clarification of the foregoing matters. In particular, a study of the east-west asymmetry of the primary radiation above the atmosphere is being conducted in the new American-built sounding rocket, the Aerobee. This rocket, sponsored by the Navy Bureau of Ordnance, has been developed jointly by the Applied Physics Laboratory of the Johns Hopkins University, the Aerojet Engineering Company, and the Douglas Aircraft Company. It carries 70 kilograms of equipment to an altitude similar to typical V-2 altitudes. Fig. 10 depicts the east-west asymmetry apparatus flown in an Aerobee to about 125 kilometers on the 5th of March, 1948 (Fig. 11). Data from this flight appear excellent, but are not completely reduced at this writing.

Simultaneously, experiments on the absorption of the primaries in massive lead absorbers are being prepared for flights in further V-2's.

It may reasonably be hoped that these and related types of experiments in the very high altitudes will add considerably to our understanding of cosmic ray phenomena during the forthcoming year.

TERMINOLOGY TALKS- J. Hugh Pruett

ANYONE who is occasionally under cloudless night skies, even though entirely too indifferent to "look up," can hardly escape some familiarity with those little flecks of light that at times flash out from seeming nothingness and flit hurriedly across the stars. They are visible usually only for a fraction of a second, and are gone as suddenly as they came into being.

"Falling stars"

In brightness and apparent form and remoteness, these little sky gliders surely seem to be stars in motion. A little neighbor girl once earnestly inquired, "If a star starts falling from right in the Big Dipper, will there always afterwards be one star missing there?" My father one fine night said calmly to his little son, "See the star fall." I was looking that way and observed the entire flight, thoroughly convinced, at the time, I had seen the star stationary shortly before it had started its motion, and that after it had slid over a short arc it distinctly stopped and continued shining in its new location. I was slightly puzzled as to why readjustments on the starry sphere were occasionally necessary—but assumed they were and asked no one to explain.

From the conversation of some adults, they too may think such phenomena are the falling of real stars from the sky. I am sure that a person with whom I recently conversed was certain of this, for he seemed quite dubious when I tried to tell him that in the "realm celestial" we find things are not always what they seem. On the best of nights good eyes do well to see as many as 2,500 stars in the entire heavens. But during the single evening of October 9, 1946, some of us saw *more* than this number apparently hurled from the sky and obliterated. The celestial dome should have been entirely depleted of its twinkling hosts, but it was still as thickly populated as ever.

Meteors, Meteorology

Meteor is the term now most commonly used in connection with the phenomenon under discussion. This comes from the Greek *meteoros,* which means "something in the air," and might include hail, rainbows, auroras, and lightning, although at present its use is confined almost entirely to the so-called shooting star. Quite paradoxically, *meteorology* now refers principally to the science of the weather. How convenient if weather specialists would consent to donate the term meteorologist to students of meteors, and for themselves be content with "aerologist."

We now know that meteors are not stars at all but phenomena of our upper atmosphere. Visible meteors are seldom as much as 100 miles above the earth's surface. To call them comets, as some persist in doing, is equally incorrect. Comets are huge objects often millions of miles in length, millions of miles from us, and instantaneous detection of their motion is not possible.

At one time scientists tried to account for meteoric phenomena by assuming that they were explosions of gas high in the air. But what the gases were, how they got there, and the cause of the explosions were hard to explain. It is now known that the luminous phase of a meteor is caused by the passage through the atmosphere of solid material at such a rapid rate — usually tens of miles per second — that friction with the air heats it to incandescence.

The solid material of ordinary meteors may be no more massive than a grain of sand or a pinhead, but extremely brilliant ones are relatively much larger. This material comes from space entirely beyond the earth's atmosphere. Some of it certainly is from the disintegration of comets. One authority believes large amounts are from the region of the asteroids. The nature of this material will be considered later.

Amateur Astronomers

Northeast Region Convenes at New Haven

THE FIRST ANNUAL convention of the Northeast region of the Astronomical League was held on Saturday, April 2nd, in Chittenden Hall at Yale University. Our hosts, the New Haven Amateur Astronomical Society, had prepared very colorful identification badges with astronomical themes for the fourscore persons who registered.

Dr. Dirk Brouwer, director of Yale University Observatory, in greeting the delegates, pointed out that as the convention was the first of its kind in the region its activities were not yet limited by precedent or tradition, and the possibilities for planning regional activities were almost unlimited.

During the business session in the morning, the proposal to continue the Stellafane convention under regional auspices was discussed, and it was decided to have a committee get in touch with the Springfield (Vt.) Telescope Makers, a league member organization, and explore the possibilities of such cooperation. After general discussion, and action by the regional council, the junior societies in the region were authorized to establish a junior regional council under the national rules governing such groups. It was proposed that the league as a whole sponsor a handbook for observers; after considerable discussion a committee was appointed to report on this matter.

An invitation to hold the 1949 regional convention in New York City in the spring was tendered by a representative of the Junior Astronomy Club, whose co-hosts will be the George Gregory Memorial Observatory of the Paul Revere Boys Club, Jersey City, and the Bergen County Astronomical Society, Teaneck, N. J.

At the election of regional officers, our present chairman, Donald S. Kimball, declared that personal affairs precluded his continuance in office. The new officers, with terms beginning September 1, 1948, are: chairman, Chester S. Cook, ATM's of Boston; vice-chairman, Stanley Brower, member-at-large, Plainfield, N.J.; secretary (re-elected), Robert Greenley, Bergen County Astronomical Society; treasurer (re-elected), Walter Reeves, Astronomical Society of Maine.

In presiding at a panel on the relation between the league and member societies, Charles A. Federer, Jr., vice-president of the league, stressed the value to the individual of attending conventions; the importance of each society sending its representative to act on the regional council; and the need for prompt handling of correspondence between regional and society secretaries. At this panel, brief talks were given by the leaders of the afternoon section meetings.

At noontime, the group photograph had to be postponed because there was a heavy flurry of snow, but the incoming cold air mass provided clear skies for observing that evening.

The section meeting on instruments, under the chairmanship of Mr. Cook, discussed a suggestion made by Dr. Brouwer some years ago. This is the use of a 35-millimeter camera of the robot type with a fairly large lens of moderate to short focal length to take sequence pictures of short-period variable stars. The exposures would be made at intervals during the night, and the plates reduced by volunteer members of the league.

Among other items discussed briefly were the optical blanks for homemade refractors now available from Bausch and Lomb Optical Company (see page 162, April *Sky and Telescope*); it was pointed out that on page 29 in the book, *Telescopes and Accessories,* by Dimitroff and Baker, there is a design for a coma-free achromat which just fits these glass specifications.

Under the chairmanship of Mrs. Grace C. Rademacher, the section on programs discussed such specific points as the establishment of an exchange lecture bureau. To facilitate this and other program improvement plans, Mrs. Rademacher suggested that copies of lecture schedules for past years be made up by individual societies. It was urged that for immediate future benefit societies in the region exchange these lists with a view toward each year scheduling an exchange of amateur lecturers. Planning of programs far in advance, and the inclusion of demonstration lectures was advocated. Junior club work was discussed, and there are indications that several groups in the region are forming junior branches.

The section on observing, which was to have been led by David W. Rosebrugh, of Waterbury, Conn., was conducted by the writer, as Mr. Rosebrugh was unable to attend for reasons of health. James Neale, of New Haven, described his methods of observing occultations, and stressed the importance of this work as well as its fascination for amateurs. Neal J. Heines, chairman of the AAVSO solar division, recommended standard methods and procedures for observing sunspots; he distributed solar division literature to many present who were especially interested.

On the subject of meteor observing, Vincent Anyzeski, of New Haven, urged more amateurs to take up this work, but pointed out that it was not easy; especially important is the development of experience in plotting over a period of years, if one's plots are to be of high accuracy. Mr. Federer discussed the need for auroral observers, especially during the current maximum of solar activity. He read letters from Mr. Rosebrugh, who feels that an au-

An informal photograph of many of the amateurs attending the Northeast regional convention at New Haven, Conn., April 2, 1948.

roral observing program is not advisable for the Northeast region; from the Montreal Centre of the Royal Astronomical Society of Canada, describing their procedure of having several naked-eye observers scheduled to give continuous coverage for a night's display; and from Dr. C. W. Gartlein, Cornell University, who is desirous of adopting a streamlined report form for naked-eye observers, and who suggested the use of binoculars and rich-field telescopes to observe and measure fine detail in auroral rays.

As announced at the observing section and the general convention session, the secretary of the Northeast region will undertake to act as a clearinghouse for inquiries on specific problems which confront any observer, instrument maker, program chairman, or other amateur. Each such inquiry will be referred to someone in the region capable of advising or helping in the problem concerned.

Guest speaker, in the afternoon following the section meetings, was Dr. John S. Hall, of Amherst College, who discussed "Stellar Photometry with Simplified Apparatus." In spite of the rather formidable title, this talk held all of us spellbound, for Dr. Hall proceeded to make clear the working of photocells and to explain how the 1P21 RCA photomultiplier tube had eliminated much of the difficulty in using photocells in many fields of science and industry.

At Amherst, Dr. Hall and John F. Jewett had just completed for this lecture a portable apparatus combining 1P21 tube, amplifier, and batteries designed for use by amateur astronomers in observing stellar magnitudes, particularly of short-period variable stars. Dr. Hall showed the apparatus and gave data on its effectiveness with various telescopes. He stated that Mr. Jewett is willing to make up duplicates (after the design has been sufficiently tested and standardized) at relatively

(Continued on page 183)

A NEW ASTEROID

On a plate taken with the 20-inch astrographic camera of the Lick Observatory March 7th, C. A. Wirtanen found a 13th-magnitude asteroid which has since turned out to have some unusual characteristics. Unfortunately for northern observers, its rapid southward motion carries it deep into southern skies during April and most of May, while its magnitude of 12.2 changes to 14.9 by the middle of May, thus making it an object suitable only for large telescopes.

Dr. L. E. Cunningham has computed the orbit of the new asteroid, and he finds that it will pass perihelion on May 21st, at a distance from the sun of about 83 million miles, within the orbit of the earth. About April 5th its distance from the earth was less than 17 million miles. The inclination of the orbit is 18°.65, and its eccentricity is 0.61.

AAVSO TO MEET AT MT. HOLYOKE COLLEGE

At the invitation of Dr. Alice Farnsworth, the spring meeting of the American Association of Variable Star Observers will be held at Mt. Holyoke College, commencing on the evening of May 21st with an open house at the Williston Observatory. On Saturday, a novel feature will be bird study early in the morning, followed by breakfast and the business meeting at 10:00 a.m. There will be papers on variable stars and other subjects. In the afternoon, after a 1:30 luncheon at the Bookshop Inn, a solar symposium will be held. Further information may be obtained from Leon Campbell, recorder, AAVSO, Harvard College Observatory, Cambridge 38, Mass.

EXHIBITS IN MAY

Coincident with the regional convention of the Astronomical League in Pittsburgh, May 14-16th, the Amateur Astronomers Association of that city is staging a display of exhibits which will interest all astronomy-minded persons who can arrange to visit it. The exhibition, at the Buhl Planetarium, will be open to the public from May 10th to 22nd. On display will be a wide assortment of instruments constructed by amateurs, including motor drives, camera mounts, and telescope accessories. A reflector and a refractor, constructed more than 65 years ago by an associate of John Brashear, will also be shown. Arrangements have been made to include exhibits brought to Pittsburgh by delegates to the regional convention.

In Schenectady, N. Y., the Schenectady Astronomy Club is planning to participate in the YMCA hobby show to be held at the Schenectady armory May 20th to 22nd. The display will include two 6-inch reflectors, an 8-inch Cassegrainian, and a 95-mm. refractor. Some 4-inch flats, a 12-inch spherical mirror, and an 8-inch Schmidt camera designed and built by George Staffa and Henry Vogel will be shown. In addition, work will be exhibited by the telescope making class conducted at the Schenectady Museum by George Staffa under the joint auspices of the museum and the society. Amateurs in the Schenectady-Albany-Troy area are invited to attend the hobby show.

CORRECTION

The 12-inch mirror of the Cassegrainian reflector of the Rice Observatory, Cumberland University, was figured by the staff of the Valley View Observatory, Pittsburgh, Pa., instead of as stated on page 120 of the March issue. G. Frank Burns, who wrote the report on the new observatory, did not have this information at the time his article was written.

THIS MONTH'S MEETINGS

Chicago: On May 11th, at 8:00 p.m., Warner Williams, of the Culver Military Academy, will speak to the Burnham Astronomical Society at the Chicago Academy of Sciences. His subject will be "Astronomy as a Culture," and he will exhibit a model of the Mount Palomar 200-inch telescope, scale 1/44.

Cincinnati: "Electronics and Astronomy" will be the subject of the lecture by Dr. W. C. Osterbrock, of the electrical engineering department of the University of Cincinnati, at the meeting of the Cincinnati Astronomical Association, on May 15th at 8 o'clock on the university campus.

Cleveland: Dr. J. J. Nassau, of the Warner and Swasey Observatory, will speak on "The Golden Age of Astronomy," at the May 28th meeting of the Cleveland Astronomical Society, 8:00 p.m. at the Warner and Swasey Observatory.

Geneva, Ill.: The Fox Valley Astronomical Society will hold its annual picnic at Aurora College on Sunday, May 23rd. At 5 p.m. there will be a lecture by Professor Ben H. Wilson, of Joliet Junior College, on "The Relationship Between Geology and Astronomy." The picnic will be at 6:30, on the Aurora College campus, and from 8 p.m. until midnight there will be sky observation, weather permitting.

Indianapolis: The Indiana Astronomical Society will hold its "Sky Information Please," led by the board of officers, on May 2nd. The meeting is at Cropsey Hall, at 2:15 p.m.

Kalamazoo: At the home of Mr. and Mrs. William Persons, 915 Parker Ave., the Kalamazoo Amateur Astronomical Association will hear a lecture by Mr. Persons on "Comets," at 8 o'clock on May 15th.

Los Angeles: Before the Los Angeles Astronomical Society, Dr. Roscoe F. Sanford, of Mount Wilson Observatory, will speak on "The Explosions of Nova T Coronae Borealis." The meeting is on May 11th, at 8 p.m., in the Griffith Observatory.

Madison: "The Life and Works of Sir William Herschel" will be the subject of Dr. J. S. Supernaw's lecture to the Madison Astronomical Society, at the Washburn Observatory on May 12th at 8 p.m.

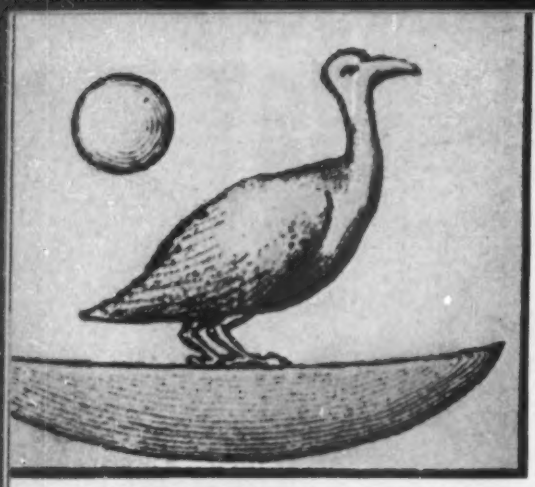
Minneapolis: Dr. S. R. B. Cooke will speak on "Mirrors, Eyepieces, and Telescopes," at the May 5th meeting of the Minneapolis Astronomy Club, 7:30 p.m. in the Public Library.

New York: The Amateur Astronomers Association will hold its annual meeting on Wednesday, May 19th, at 8:00 p.m. in the American Museum of Natural History. There will be motion pictures, reports of officers and committees, elections, and entertainment.

Pittsburgh: At the May 14th meeting of the Amateur Astronomers Association, D. W. Rial, associated with the Carnegie Museum at Pittsburgh, will give an illustrated lecture on "Sundials." The meeting is at the Buhl Planetarium, 8:15 p.m., and precedes the regional convention on Saturday, May 15th.

Stamford: Dr. Charles P. Olivier, of Flower Observatory, will be the speaker at the Stamford Amateur Astronomers, Friday, May 28th, 8 p.m. at the Stamford Museum.

Washington: Dr. George A. Gamow, professor of theoretical physics at George Washington University, will be guest lecturer of the National Capital Astronomers on Saturday, May 1st, at 8 p.m. in the National Museum. His subject is to be "Origin of the Universe."



According to an ancient Egyptian belief, a celestial goose daily laid an egg which hatched into the sun.

MEN AND STARS

BY ROBERT R. COLES, *Hayden Planetarium*

... The stars are the apexes of what wonderful triangles! What distant and different beings in the various mansions of the universe are contemplating the same one at the same moment. — THOREAU

THE VERY STARS that we may watch tonight shone over the ancients and even before the dawn of history. While civilizations have come and gone, the "everlasting hills" have disappeared, the stars have remained to remind us of ages now lost in the mists of antiquity. The constellations have changed only slightly, and the planets obey the same laws that governed them when man first appeared on the earth. Ever since that forgotten time when he became aware of the sky picture, its beauty has thrilled him and its endless wonders have challenged his curiosity.

Some phases of our lives would be quite different without the stars. Aside from their importance to astronomers, they have had an incalculable influence on philosophy, theology, history, literature, music, art, and the sciences. And the pseudo-science of astrology has left its mark on human affairs.

Although we see the same stars that the ancients observed, we interpret them differently. The story of man's strivings to understand the architecture, the mechanics, and the meaning of the universe is as old as the story of civilization itself. Just as every corner of these United States brings to mind highlights in the history of our nation, so every region of the star-filled sky suggests interesting achievements in the history of astronomy. Thus a view of Jupiter's satellites recalls for us the story of Galileo's pioneer observations with the telescope during the early 17th century. Or the sight of a comet brings to mind the achievements of Halley. Even the names of the constellations are so mingled with mythology, history, and geography that it would require a lifetime to discover all about them. The motions of the planets, the behavior of variable stars, and the phenomena of solar and lunar eclipses, each suggests interesting chapters in the story of astronomy.

It must have been at an early time that man came to recognize the value of stars as beacons for orientation and as aids to find his way at night. And men soon learned to estimate time by the sun and stars. Calendars, based upon the phases of the moon and the heliacal risings of bright stars, were invented in ancient Babylon and Egypt. The Chaldeans knew how to predict eclipses by means of the saros, although they did not fully understand the mechanism of an eclipse. These achievements of the ancient star watchers emphasize the great antiquity of the science and call attention to the fact that man's interest in the heavens reaches back farther than we know. Astronomy has been described as the oldest of the physical sciences.

It has been said that astronomy came of age with the Greeks, who gained their first knowledge of the heavens from the Babylonians. The Greek philosopher, Thales of Miletus (640-546 B.C.), taught that the earth was round and that the moon shone by reflected light. Anaximander (c. 611-547 B.C.) explained the obliquity of the ecliptic and suggested the bold idea of the plurality of worlds. About 280 B.C. Aristarchus taught that the earth revolved around the sun and that the distance of the sun from the earth was insignificant in comparison with that of the stars. Two more famous Greek astronomers were Eratosthenes, who measured the circumference of the earth, and Hipparchus. The latter made one of the early star catalogues, classified the stars visible to the unaided eye into six magnitudes, and discovered precession, more than a century before the Christian era.

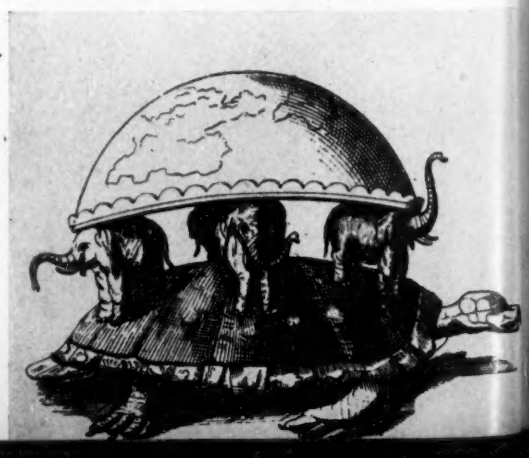
There have, of course, always been conflicting theories in astronomy, and the ideas of these philosophers were often scorned by the majority. Most people were inclined to accept things as revealed by casual observation, and such visual evidence suggested that the earth was at the center of the universe. Often, in the progress of science, incorrect theories enjoy popular support for centuries. This was true of the famous geocentric theory of Ptolemy (100-170 A.D.), which was accepted as orthodox astronomy for about 14 centuries. We are sometimes inclined to view this theory as naive, but if we were called upon to analyze the sky picture with only the knowledge the ancients possessed, we would judge them more charitably.

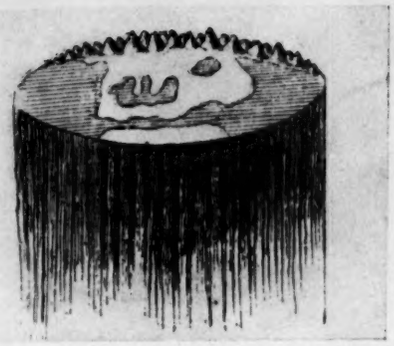
After Ptolemy, scientific progress practically came to a standstill and, except for the contributions of the Arabians, a state of stagnation prevailed in all sciences for centuries. The next really great name in astronomy is that of Nicolaus Copernicus (1473-1543), whose famous heliocentric theory was published in the year of his death. And while this met with strong opposition, its appearance heralded the dawn of a new period in the progress of astronomy. In this era the names of Tycho, Galileo, Kepler, and Newton shine forth like 1st-magnitude stars, and their achievements retain their great significance with the passing years. These are the men who laid the foundation of modern astronomy. They unscrambled the sky picture and discovered the basic laws that govern the behavior of the heavenly bodies.

Although the idea of a sun-centered system had been suggested by the Greeks, it never enjoyed popular support and was nearly forgotten during the period in which the Ptolemaic theory was accepted. Even the Copernican theory was far from perfect. It described the planets as following a uniform circular motion around the sun, and retained some of the complexities of the Ptolemaic theory. But, on the whole, it was much simpler and did not require the very distant stars to circle a stationary earth every 24 hours.

One stumbling block to acceptance of the Copernican system was the inability to detect any parallactic shift in the stars as the earth revolved around the sun. Tycho Brahe (1546-1601), who built the finest instruments before the telescope and carried out endless precise observations, failed to detect this parallax in the stars and therefore rejected the Copernican theory. Of course, no one then imagined the tremendous distances of even the nearest stars. But although Tycho did not support the heliocentric theory, he did much to advance astronomy. Among other things

The Hindus at one time conceived of a hemispherical earth supported by elephants standing on a tortoise.





Ancient island folk believed the earth to be a disk in water, with its roots extending into the depths below.

he conducted a long series of very accurate observations of the planets that later proved of great value to Kepler.

It was Galileo Galilei (1564-1642) who discovered the first visual evidence in support of the Copernican theory. When he turned the first telescope on the heavens in the early 17th century, he began a search of the universe that is still in progress. In his discovery of the four large satellites of Jupiter he proved that such a system as Copernicus described can and does exist. And in his observation of the phases of Venus, he found convincing proof that it circles the sun within the orbit of the earth.

Johannes Kepler (1571-1630), who worked for awhile with Tycho, and is said to have carried on friendly correspondence with Galileo, is most famous for his laws of planetary motion, which were based largely upon the planet observations that had been made by Tycho. Kepler found that:

I. Each planet moves in an ellipse which has the sun at one of its foci.

II. The radius vector between each planet and the sun passes over equal areas in equal intervals of time.

III. The cubes of the mean distances of any two planets from the sun are to each other as the squares of their times of revolution around the sun.

The statement of these laws by Kepler helped to prove the inherent orderliness of the solar system. But they were purely empirical in nature; no one knew why the planets behaved in the manner that he described. It remained for Isaac Newton (1643-1727) to describe the "why" and to explain it in his famous law of gravitation which stands today as one of the greatest contributions ever made to physical science.

All five of these men wondered about the stars just as we do today, and just as the ancients wondered about them before history was written. But as they kept their eyes on the stars they kept their feet soundly planted on the earth, and with penetrating minds they solved some of the most perplexing riddles of the universe.

NEWS NOTES

By Dorrit Hoffleit

NOISE KEEPS CORONA HOT

The temperature of the sun's corona is of the order of a million degrees. How is this high temperature maintained? This is the problem Dr. Martin Schwarzschild, of Princeton University Observatory, sets out to answer. In the *Astrophysical Journal* he reports that acoustical waves of energy are produced by the turbulence of the solar granules (familiarly known as rice-grain structure). The granules may be likened to gas bubbles hundreds of miles in diameter, each lasting only a few minutes. At any one time only about 1/10 of the sun's surface is covered with granules.

The granule-produced compression waves do not visibly affect the reversing layer of the sun's atmosphere as they pass upward, but some 500 miles above the photosphere the mechanical energy of the "noise" is converted into heat sufficient to compensate for the heat loss of the corona by radiation, thus keeping the corona hot.

THE ULTIMATE STANDARD

The address of the Ives medalist for 1947 before the Optical Society of America illustrates why Dr. W. F. Meggers, of the National Bureau of Standards, was nominated "dean of American spectrographers," and the medal for distinguished work in optics conferred upon him.

Tracing the development of the choice of the cadmium red line as the provisional standard of wave length, Dr. Meggers pointed out that Michelson and Morley in 1889 had stated that the mercury green line would in all probability become the ultimate standard, because of its sharpness. In 1892, however, Michelson discovered that the hyperfine structure of this line made it ineligible, and the cadmium line became the best choice, being "the sharpest spectral line to be found in nature."

Although the presence of isotopes of an element does not necessarily lead to hyperfine structure (cadmium has eight isotopes), the complex structure of the mercury lines was due to the unfavorable mixture of seven isotopes. Otherwise the mercury would have made a better standard because it fulfills many other requirements and desirable features for a standard. For example, it is unique in radiating narrow lines at low temperature and pressure (see *Sky and Telescope*, June, 1946, page 10). Hence, if a single even-mass isotope of mercury could be isolated or manufactured in sufficient quantity to make bright, durable lamps, the mercury green line would be much preferred over the cadmium red. In 1940, gold bombarded by neutrons in a cyclotron was shown to be transmuted to give a pure mercury isotope of atomic weight 198. Since 1945, the bombardment of gold by neutrons in a chain-reacting pile has yielded sufficient pure material for bright, durable lamps. The provisional measurements of wave lengths made were reported by Dr. Meggers to be 100 times more accurate than were attainable with natural mercury. The new results are accurate to one part in 20 million.

ANNIE J. CANNON LECTURESHIP

A memorial to Harvard's revered woman astronomer, Dr. Annie J. Cannon, is being proposed by the University of Delaware in the form of an annual lectureship in science. Miss Cannon was a native of Dover, Kent County, Del., and although her career was pursued in Cambridge, her ties with her native area were always strong and affectionate. The University of Delaware hopes to secure funds amounting to 20 thousand dollars as an endowment for the lectureship, thereby furthering the intellectual curiosity which characterized Miss Cannon's life and career, as well as bringing to the local campus some of the most outstanding scientists of our time.

Mrs. John Pilling Wright, of Newark, Del., is chairman of the Annie Jump Cannon memorial committee, and Mrs. Margaret Walton Mayall, of Harvard Observatory (who was Miss Cannon's chief assistant), is on the committee.

WEATHER BY STARLIGHT

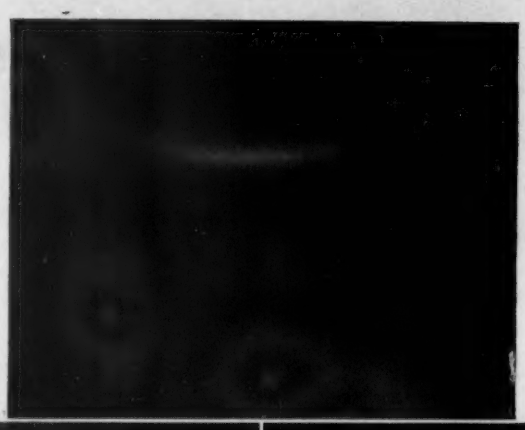
The new journal *Weatherwise* reports on the application of an astronomical tool to the art of weather prediction. As many as 10 years ago Dr. John S. Hall, of Amherst College, used a photoelectric spectrophotometer for studying stellar spectra. With his instrument, the intensity of starlight was proportional to the velocity with which a very small electrometer needle crossed the field of a microscope. Dr. Hall found that the passing of clouds stopped the needle — even invisible water vapor could then be detected.

With the photomultiplier tube and the infrared-sensitive lead-sulfide cell, the strong absorption of water vapor in the infrared can be compared with other spectral regions to give a measure of the moisture content of the air between the observer and such a star as Polaris, which is convenient because of its small change in position. Plans are now being carried out for its continual day and night observation at Amherst.

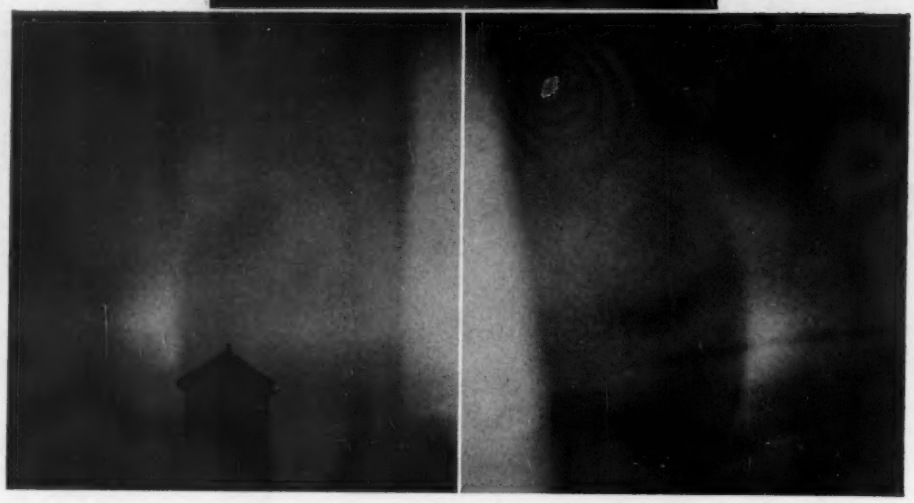
STAMFORD HALO COMPLEX

By Glenn E. Coven

Stamford Amateur Astronomers



Centered on the zenith is the circumzenithal arc, with red toward the sun, if there is color in the arc.



A 22° halo with sun dogs and a circumzenithal arc, photographed by William Nussbaum at Stamford, Conn., January 27, 1948, about 9:30 a.m. EST.

SEEN frequently by those of us who like to turn our eyes skyward is the ring around the sun, or more precisely, the halo of 22°. It is the result of refraction of the sun's light through myriads of tiny ice crystals — the substance of cirrus and cirrostratus clouds — floating high above the earth, and is the commonest of a number of refraction phenomena produced in this way.

Sometimes, when conditions are favorable, other less common and more spectacular optical effects are seen in the sky, especially during the winter months. An occurrence of this sort greeted observers in southwestern Connecticut on the cold morning of January 27th, this year. As seen at Stamford the sun rose flanked by two mock suns, or sun dogs as they are sometimes called from their fanciful role as attendants or followers of the sun. As the sun climbed into the sky these bright spots of light, each at an angular distance of about 22° from the sun, maintained the same apparent distance from the horizon as did the sun itself. At times they showed some color. The halo of 22° was visible in part and was seen in its entirety later in the morning. Portions of the halo of 46° were seen intermittently, with a tangent arc at one point, and high above the sun the display was crowned with a brilliant rainbow-like circumzenithal arc, easily the most spectacular feature in this halo complex.

The conditions favorable for the production of these atmospheric optics persisted throughout the day. Not much could be made out during the middle part of the day but in the afternoon most of the features reappeared, especially the mock suns. Let us have a brief look at some of the details of their formation.

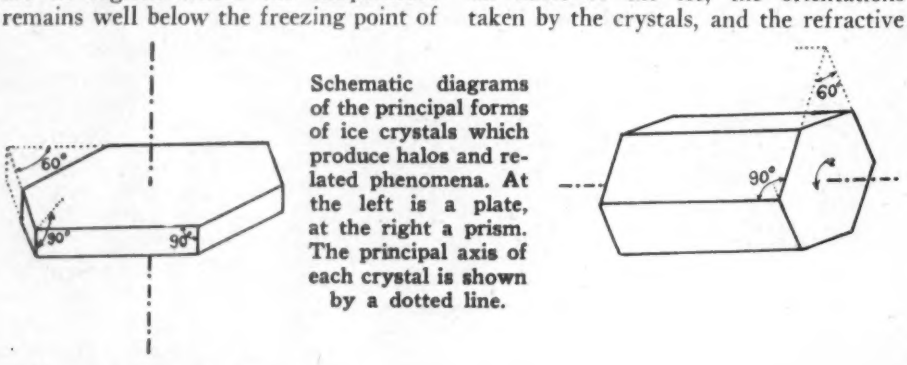
Cirrus and cirrostratus clouds, floating four to seven miles above the earth, are in regions where the temperature remains well below the freezing point of water, winter and summer. Consequently, when the invisible water vapor in the atmosphere condenses to form these clouds it goes directly to the solid, crystalline state and forms minute six-sided plates and prisms, the characteristic *habits* of ice crystals, as the crystallographer would say. In still air these tiny forms settle very slowly, and in so doing they orient themselves so that their greatest surfaces are presented to the resisting medium (the air) through which they are falling. Thus, plates fall flat, needle-like prisms fall horizontally. In turbulent air, the usual condition at the windy cirrus level, the orientation of the crystals would be quite random. This orientation is an important factor in the production of the refraction phenomena, as we shall see.

If we take into account now the crystal habit of the ice, the orientations taken by the crystals, and the refractive index of ice, and apply our knowledge of the behavior of light, we can calculate that light from the sun (or moon), in passing through these crystals, should be refracted and reflected in certain definite ways to produce certain visible patterns of light and color. How does this work out for specific examples?

The halo of 22°, the encircling ring at approximately that angular distance from the sun, is produced by refraction of the sun's light through the 60° angles of the ice crystals when they are in random orientation. The ring usually shows color, with red on the inside, because the different colors of which white light is composed are refracted slightly different amounts. The halo of 46°, a larger ring at an angular distance of about 46°, is produced in exactly the same way except that the light is refracted through the 90° angles of the crystals.

The mock suns, known to the meteorologist as the *parhelia* of 22°, result from refraction through the 60° angles of the ice crystals when a majority of them are oriented with their sides vertical. In a sense they represent a special case of the 22° halo and appear only when conditions allow the necessary mass orientation.

The circumzenithal arc frequently occurs along with the mock suns and consists of a rainbow-like arc at about 46° above the sun, with its geometrical center at the zenith. It therefore curves



Schematic diagrams of the principal forms of ice crystals which produce halos and related phenomena. At the left is a plate, at the right a prism. The principal axis of each crystal is shown by a dotted line.

FORMATION OF THE DIFFERENT PARTS OF HALO PHENOMENA

How the feature is formed	*Plates, main axis vertical*	*Random distribution*	*Prisms, main axis horizontal*
Refraction on 60° faces of crystals	Parhelia (25)	22° halo (100)	Upper tangent arc of 22° halo (8)
Refraction on 90° faces	Circumzenithal arc (4)	46° halo (2.2)	Lower side arc of 46° halo
Reflection from horizontal faces	Lower sun (seen only from a height)	——	Vertical pillar thru sun (2.5)
Reflection from vertical faces	Horizontal circle (1.4)	——	Horizontal circle and pillar—a cross (0.4)
By double reflection	Additional 120° countersun (0.1)	——	180° countersun

The figures in parentheses indicate the relative frequency with which the respective forms are observed, on the basis of 100 occurrences of the 22° halo.

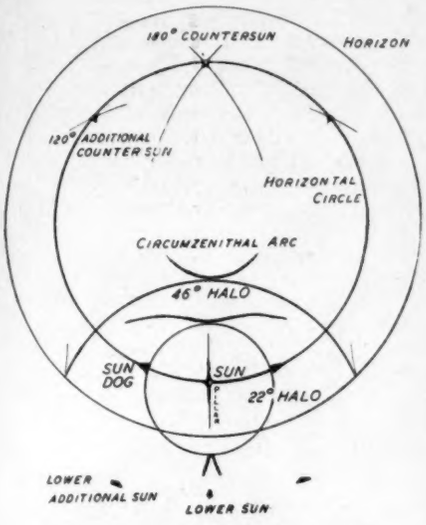


Diagram by Vladimir Vand.

in a direction opposite to the above-described halos, and its colors are usually brilliant and well defined, with the red on the side toward the sun. Like the mock suns, its production depends on a vertical orientation of large numbers of crystals, and is the result of refraction of light through the 90° angle between the flat tops of the crystals and their vertical sides, as the crystals rotate about their vertical axes. The circumzenithal arc is theoretically impossible after the sun reaches a height of 32° 12′ above the horizon, since the light then undergoes total reflection from the internal side of the vertical crystal face instead of refraction through this face.

It will be noted that the two most brilliant features of this complex, as seen at Stamford, the mock suns and circumzenithal arc, require a definite orientation of large numbers of crystals. The two halos, the result of random orientation, were much less brilliant. It is conceivable that large numbers of crystals in both random and definite orientations could exist concurrently at the same atmospheric level. Another explanation might be that the two necessary conditions existed simultaneously at different levels in the atmosphere.

These refraction halos, incidentally, are not to be confused with the familiar summertime rainbows which are produced by water droplets and are seen in the sky opposite to the sun.

LUNAR HALO PHENOMENA

The following may not be within the province of astronomy, but I wonder if there was visible from your location a moon dog about 20 degrees south of the moon around 9:30 p.m., March 25th. This was quite apparent here, and the spot seemed to be in a light haze, although most of the sky was very clear. It showed varying prismatic colors, sometimes extending a "tail." HARRY W. POOR

Georgetown, Mass.

ED. NOTE: Moon dogs and other associated phenomena were seen widely over New England at the time Mr. Poor made his observations. At Belmont, Mass., where the accompanying photograph was taken, each moon dog (paraselene) was brilliant in all colors of the spectrum, first stronger on one side of the moon and then on the other. The circumzenithal arc and portions of the horizontal circle were also easily seen, as well as the upper tangent arc attached to the top of the 22° halo, which is shown but not labeled in Vladimir Vand's drawing.

A moon dog and horizontal circle, photographed by Robert E. Cox, March 25, 1948.

Also, while traveling westward toward Springfield, Mass., the afternoon of March 1st, the editors saw a very brilliant sun dog with strong colors; a heavy snow fell the next day.

In his article translated in the October, 1940, issue of The SKY, Dr. Vand states that cirrus clouds usually grow too fast to allow the formation of the large, simple crystals needed for halo formation, and implies that cirrostratus clouds give better crystals for this purpose. The plates are often only 1/10 as thick as they are wide, and the prisms are in length from one to five times their thickness. Sometimes the two forms are attached together.

By combining the information in the table with careful analysis of possible paths of light from the sun to the observer through the two crystal forms, one may sketch a diagram to account for each of the halo phenomena. For instance, it is easy to show that in random orientation only those plates whose axes are tangent to the circle can take part in producing the usual 22° halo; the refraction is through two faces on the outside edge of each plate.

In Focus

THE THIRD in the back-cover series of Porter drawings of the 200-inch instrument depicts an observer photographing at the prime focus of the world's largest telescope. The rectangle in the small drawing in the right-hand corner includes the area shown in this picture.

Suspended in his six-foot cage, 55 feet above the mirror's surface, the astronomer rides in the telescope while making his observations. Thus the conventional Newtonian diagonal is for the first time completely eliminated. The conically shaped floor and adjustable chair make it possible for the observer to occupy a comfortable position, nearly vertical, at all times. A set of dials and switches, shown in the drawing on the far wall of the cage, enables him to know the position on the celestial sphere toward which the telescope is pointing. Telephone contact is maintained with an assistant located at the control board under the north pier on the main floor.

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suggestions for a second telescope
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BOOKS AND THE SKY

THE SCIENTISTS SPEAK

Warren Weaver, Editor. Boni and Gaer, New York, 1947. 369 pages. $3.75.

CURIOSITY about the world is not restricted to scientists and philosophers. It exists, to a greater or lesser degree, in most individuals of every age. But because most people must devote the major portion of their waking hours to the serious business of making a living, they do not have the necessary time or energy to investigate personally the many mysteries that challenge their curiosity, or even to read, more than casually, in those fields that interest them.

The Scientists Speak is a book that should appeal to just such people. It is a compilation of 81 talks given during intermissions of the New York Philharmonic Symphony broadcasts by top-flight scientists in many varied fields of research. It is edited by Warren Weaver, of the Rockefeller Foundation, who served as chairman of the advisory committee that arranged the broadcasts. There are 15 chapters, the first of which, on "Science and Complexity," by Dr. Weaver, establishes the general theme of the book. The remaining chapters, "The Science of the Earth," "The Science of the Sky," "The Natural and Social Sciences," and so on, are each made up of a half dozen or so short talks by recognized authorities. These talks include such topics as "The Utility of Meteors," by Harlow Shapley, "Science and Our Nation's Future," by Arthur H. Compton, and "The New Geography," by Isaiah Bowman. Preceding each chapter is an introductory section prepared by the editor, in which he summarizes a few of the important highlights of the field covered in the ensuing pages.

These talks, of about 3½ pages each, are offered for the non-scientist. It is not expected that the astronomer, the biologist, or the chemist will find in them very much with which he is not already familiar, at least in his own field. On the other hand, the talks are designed to serve the sciences in an important way. If pure research is to enjoy the popular support it must have, then the public must be enlightened as to its meaning and values. Today, more than ever, the newspapers and radio carry stories from every science front. The columns of the daily press discuss everything from neutrons to galaxies, and the reader who would keep abreast of the times must become familiar with the inner workings and hidden mechanisms of the new world of science in which he lives. It is books like this that serve such a purpose well.

For those who care to delve more deeply into the realms that are here introduced, a generous bibliography is supplied at the end of the book.

ROBERT R. COLES
Hayden Planetarium

MANUAL OF ASTRONOMY

R. W. Shaw and **S. L. Boothroyd.** Appleton-Century-Crofts, Inc., New York, 1947. Third edition, 294 pages. $3.00.

THE RECENTLY ISSUED third edition of Shaw and Boothroyd's "Manual of Astronomy" contains 47 exercises, of which 22 require no equipment and no data other than that provided in the manual, and 25 require separate equipment ranging from working photographs to fairly elaborate spectroscopic equipment.

The manual takes the student further into advanced astronomy than any others which have come to the attention of this reviewer. In addition to the conventional telescopic observations of planets, visual observations of the apparent motions of celestial objects, and work with the celestial sphere, the volume contains exercises in the measurement of the displacement of absorption lines and the subsequent computations of radial velocities, observations of spectral intensity distributions, studies of galactic structure from data on the distribution of novae, and others of this level of difficulty. In all cases the explanations and procedures are presented in mathematically elementary terms. In many cases the authors have exhibited considerable ingenuity in circumventing mathematical or technical elaborations without loss of clarity or validity.

This book should be useful to amateur astronomers as well as students, and particularly to those amateurs who would like to gain some additional insight into the work of professional astronomers without becoming involved in advanced mathe-

NEW BOOKS RECEIVED

The Control of Atomic Energy, *Newman and Miller,* 1948, *Whittlesey.* 434 pages. $5.00.

Subtitled A Study of its Social, Economic, and Political Implications, this book discusses the 1946 atomic energy act, the problem of military or civilian control. Security, commercial, legal, and business aspects are covered.

The Growth of Physical Science, *Sir James Jeans,* 1948, *Cambridge University Press, Macmillan.* 364 pages. $4.00.

A noted science authority traces the history of physical science from its early beginnings in Babylonia and Egypt to our modern era. Proofs of this book were revised by the author shortly before his death in 1946, and this is the first American edition.

Sky Publications

Cosmic Rays 50c
Here is the story of the "mysterious and unseen but powerful visitors from space," graphically told, with some background in atomic physics. By W. F. G. Swann, director of the Bartol Research Foundation.

Relativity 50c
The astronomical implications of the general theory uniquely described in the language of the intelligent layman. By Philipp Frank, Harvard University.

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STAFF: *Director,* Wagner Schlesinger. *Other lecturers:* Harry S. Everett, Albert B. Shatzel.

May: STEERING BY THE STARS. Navigation, surveying, and the determination of time all depend upon astronomical observations. The basic principles involved are made simple through use of the planetarium instrument.

June: STORY OF THE CALENDAR.

BUHL PLANETARIUM

Federal and West Ohio Sts., Pittsburgh 12, Pa. Fairfax 4300

SCHEDULE: Mondays through Saturdays, 3 and 8:30 p.m.; Sundays and holidays, 3, 4, and 8:30 p.m.

STAFF: *Director,* Arthur L. Draper. *Other lecturers:* Nicholas E. Wagman, J. Frederick Kunze.

May: FORECASTING THE WEATHER. Presenting the various simple weather signs we all can use in forecasting the weather, with special emphasis on different types of clouds.

June: THE MOON IN JUNE.

FELS PLANETARIUM

20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600

SCHEDULE: 3 and 8:30 p.m. daily except Mondays; also 2 p.m. on Saturdays, Sundays, and holidays. 11 a.m. Saturdays, Children's Hour (adults admitted).

STAFF: *Director,* Roy K. Marshall. *Other lecturers:* I. M. Levitt, William L. Fisher, Armand N. Spitz, Robert W. Neathery.

May: END OF THE WORLD. Various ways in which it has been said that the world might end will be discussed and demonstrated with special and spectacular equipment.

June: LIFE ON OTHER PLANETS.

GRIFFITH PLANETARIUM

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SCHEDULE: Wednesday and Thursday at 8:30 p.m. Friday, Saturday, and Sunday at 3 and 8:30 p.m. Extra show on Sunday at 4:15 p.m.

STAFF: *Director,* Dinsmore Alter. *Other lecturers:* C. H. Cleminshaw, George W. Bunton.

May: THE 200-INCH TELESCOPE. There will be a description of the 200-inch telescope, with the planetarium showing objects of the types which most commonly will be observed by the largest telescope.

June: UNDER THE SOUTHERN CROSS.

HAYDEN PLANETARIUM

81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.

STAFF: *Honorary Curator,* Clyde Fisher. *Chairman and Curator,* Gordon A. Atwater. *Other lecturers:* Robert R. Coles, Catharine E. Barry, Shirley I. Gale, Edward H. Preston.

May: MEN AND STARS. The contributions of men like Galileo, Newton, and the Herschels make this one of the most interesting and dramatic planetarium demonstrations of the year.

June: COLOR IN THE SKY.

matics. Some of the exercises which appear especially well adapted to this purpose are:

Rotation of Jupiter by Doppler Effect: A portion of the spectrum of Jupiter is reproduced, sufficiently enlarged so that the displacements and tilts of the lines can be measured with a ruler, or by comparison with an accompanying scale. A complete explanation of the reduction procedure is given, and the reader can determine from his own measurements the rotational velocity of Jupiter, as well as its radial velocity at the time the spectrum was photographed.

Distribution of Galactic Novae: A table of the positions of all novae from 1500 to 1940 is given. The reader can plot these and deduce the location of the galactic plane, the fact that the sun is located eccentrically, and the approximate direction to the center of the galaxy.

Orbit of an Asteroid: Six observations of the right ascension and declination of Amphitrite are given, with directions for a simple graphical procedure which reveals the true position of the asteroid in space and leads to a complete determination of its orbital elements.

Solar Temperature by Planck's Radiation Law: A set of intensities of the photosphere and of a sunspot are given, with an explanation of a procedure for obtaining temperatures from a comparison with a set of Planckian curves, or from Wien's law.

VICTOR GOEDICKE
Ohio University

NORTHEAST REGION

(Continued from page 177)

low cost. A lively question period followed that indicated quite a few of those present were interested in observing with such equipment.

The late afternoon was featured by a tea at the Yale Divinity School, served by the ladies of the New Haven society and the university. Inspection of the instruments and equipment of the observatory concluded the afternoon program. We were then on our own through the dinner period, after which we observed with the 9-inch Reed refractor and amateur instruments. So closed one of the most enjoyable and instructive days your reporter can remember.

ROBERT GREENLEY
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Caldwell, N. J.

SOLAR DIVISION CONCLAVE

On Sunday, April 4th, a meeting of the northeastern region of the solar division of the AAVSO was held at Yale University Observatory. In addition to direct observing of the sun and discussion of methods of observing and reporting, there were motion pictures and an illustrated talk by Alan Shapley, of the National Bureau of Standards. He described the methods used in reducing sunspot observations and the establishment of a new American relative sunspot number.

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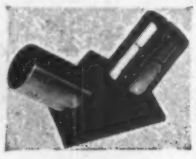

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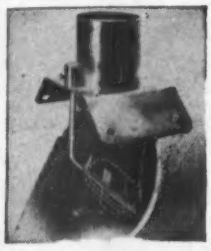

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THE COMPOUND REFLECTING TELESCOPE — I

By Allyn J. Thompson

AFTER A HALF CENTURY of fruitless struggle with the early refractor, it was to be expected that astronomers, appreciative of the advantages of long focal lengths and high magnifications, should seek a means of retaining these features in a reflecting telescope. A most logical solution, worked out by James Gregory in 1663, was the employment of a small concave mirror of ellipsoidal figure placed beyond the focus of a paraboloidal primary mirror. The arrangement is shown in Fig. 1, the ellipsoid **s** being so placed that its first focus is coincident with the focus **F** of the large mirror. It is an interesting property of the ellipsoid that if a point object is placed at one of its foci, a perfect image will be formed at the other, and as the primary image point formed at **F** may be regarded as such an object, an image of it will be found at **f**. If instead of being a point, the object has appreciable dimensions, its image at **f** will be enlarged in the ratio of **fs/Fs**. In effect, the focal length of the primary mirror is similarly amplified. Inversion of the image occurs in this second reflection, but as the primary mirror has already introduced an inversion, the final image appears erect.

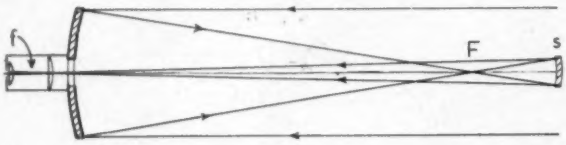

Fig. 1. Paths of light rays in the Gregorian telescope.

In 1672, investigations by Sieur Cassegrain into the geometric properties of reflecting surfaces led to his description of another compound telescope (Fig. 2) likewise employing a paraboloidal primary mirror, but having a convex secondary placed inside the primary mirror's focus. This small secondary mirror was given a hyperboloidal figure, the optical properties of which are illustrated in Fig. 3. If, in that diagram, the convex surface of the hyperboloid at **V** be reflecting, then divergent rays from a point source of light placed at the conjugate focus **f'** will be reflected as if they had their source in the virtual focus **f**. Or if convergent rays **X** and **Y** are aimed at **f**, they will be reflected to a focus at **f'**. In the telescope, then, if the latter rays come from a paraboloidal mirror and head for a focus at **f**, which point is also the virtual focus of the hyperboloidal secondary, they will be brought to a real focus at **f'**. In the case of an extended object, the image at **f'** will be inverted, and enlarged in the ratio of **Vf'/Vf**. In this arrangement the telescope tube will be considerably shorter than is possible with Gregory's design. As the Cassegrainian is astronomically the more practical of the two instruments, it will be given first consideration, although it was preceded in history by the Gregorian.

Why Make a Compound Reflector? Because of the difficulty of attaining the required optical perfection, it is seldom that one finds a telescope of this type that will produce the same exquisitely defined image of which a first-class Newtonian or a refractor is capable. With proper correction of the mirrors, however, excellent images will result. A most beneficial feature of this type of telescope is that it may be only a fraction of the length of either a Newtonian or a refractor of equal focal length. Thus it is more convenient

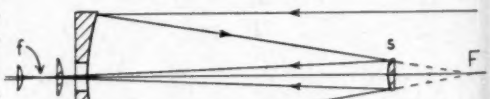

Fig. 2. Paths of light rays in the Cassegrainian telescope.

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EDITED BY EARLE B. BROWN

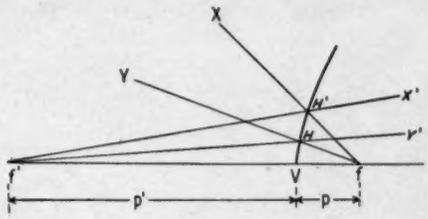

Fig. 3. Geometric properties of the hyperboloid.

to handle, and it is vastly steadier on its mounting. While it may cost a little more to build than the Newtonian, and present more difficulties, it offers the advantage of larger images, and somewhat greater comfort in observing.

Equally high magnification can of course be had with a Newtonian simply by using an eyepiece of very short focal length, but it is tiresome to keep one's eye practically glued to the lens of such an eyepiece, and at the same time to concentrate attention on the object under observation. By way of contrast, thanks to the greater focal length of the compound reflector, eyepieces of comparatively low power, affording a much more comfortable eye relief, can be used, and prolonged observing can be indulged in without fatigue.

Neither the Cassegrainian nor the Gregorian is well suited for daytime use, due to daylight flooding the eyepiece and fogging out the images. This difficulty can be overcome, however, by extending short lengths of tubing toward each other from both the secondary mirror and the perforation in the primary, which act as light baffles. But for these to be completely effective, the tube from the secondary must be of such diameter as to obstruct an unduly large and unwarranted portion of the light entering the telescope; the amount of this obstruction can be reduced, however, by extending the main tube of the telescope a reasonable distance beyond the secondary support. Another method of eliminating sky fog has been devised by H. E. Dall (**Scientific American,** May, 1939), who introduces a triplet erecting lens and a stop in front of the perforation in the primary mirror.

The compound reflector is a perfect instrument for photographing the moon and planets. The long effective focal length gives a good-sized image at the focal plane which may be photographed without enlargement through an eyepiece. Some observers like to focus a compound telescope by making very slight adjustments in the position of the secondary mirror.

It has sometimes been stated that the image formed by the compound reflector is the same as if formed from a mirror of the same diameter as the primary and with a focal length equal to the equivalent focal length of the combination. This may be shown by extending the rays converging to the axial image point backward to where they intersect the original rays approaching the edge of the primary mirror. However, the location of this fictitious primary is not the same for all points in the field of view. The situation is about as shown

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23 mm Dia.	162 mm F.L.	coated	ea.	1.25
23 mm Dia.	184 mm F.L.	coated	ea.	1.35
25 mm Dia.	122 mm F.L.	coated	ea.	1.25
26 mm Dia.	104 mm F.L.	coated	ea.	1.25
29 mm Dia.	54 mm F.L.	coated	ea.	1.25
31 mm Dia.	124 mm F.L.	coated	ea.	1.50
31 mm Dia.	172 mm F.L.	coated	ea.	1.25
32 mm Dia.	132 mm F.L.		ea.	1.50
34 mm Dia.	65 mm F.L.	coated	ea.	1.50
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in Fig. 4, where it is seen that the light funneled into three separate points in the image plane stems apparently from three separate mirrors, the axes of the several cones intersecting in the conjugate focus of the secondary. For the 34-minute field of the 6-inch telescope presently to be described, the composite fictitious mirror, at the equivalent focal distance of 102 inches from the image plane, would have a diameter of 9¼ inches.

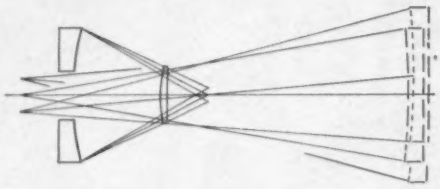

Fig. 4. Fictitious mirrors of a Cassegrainian telescope. To avoid confusion, not all the rays are shown, and the "mirrors" are not positioned exactly. Only the lowest part of the "mirror" corresponding to the topmost image in the focal plane is shown.

Paraboloid to Sphere. Perhaps the one thing most responsible for impeding the early progress of the Cassegrainian telescope was the problem of producing the hyperboloidal figure on the secondary mirror. Figuring difficulties are still a barrier to greater popularity of this type of telescope, although ways have been found to simplify testing. It is rather well known that the figures given to the primary and secondary mirrors need not be the ones proposed by Cassegrain. His use of the paraboloidal primary and hyperboloidal secondary was a beautiful application of pure geometry, but it is a fact that practically any figure can be given to the primary mirror, provided its axial aberration is compensated by an appropriate figure on the secondary.

Consideration must be given, however, to the images of points that do not lie on the axis. The most serious off-axis aberration of the reflector is coma, resulting from a failure of the different zones of the mirror to combine rays from a field star in a single focus. Oblique incident rays reflected from the inner zones come to a focus closer to the axis than do rays from zones lying farther out on the mirror. The image for each zone is in the form of a circle, varying in size with the radius of the zone, and the circles are overlapping. The net result is that, in the case of a star situated some distance from the center of the field, a blurry, comet-shaped image, pointing toward the axis, is found. In a paraboloid, the effect of this aberration increases with the distance from the axis, and inversely as the square of the focal ratio.

Fortunately, the combination of paraboloidal primary and hyperboloidal secondary makes substantial correction for this defect. The correction is not complete, but becomes about equal in quantity to what would be obtained from a single mirror of the same focal length as that of the combination. Some curvature of the field is introduced, but for the small angular field that is used in the Cassegrainian, it is of negligible amount.

(To be continued)

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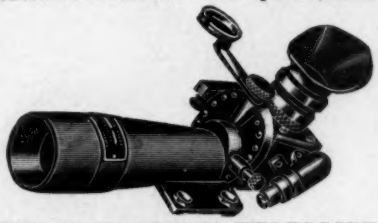

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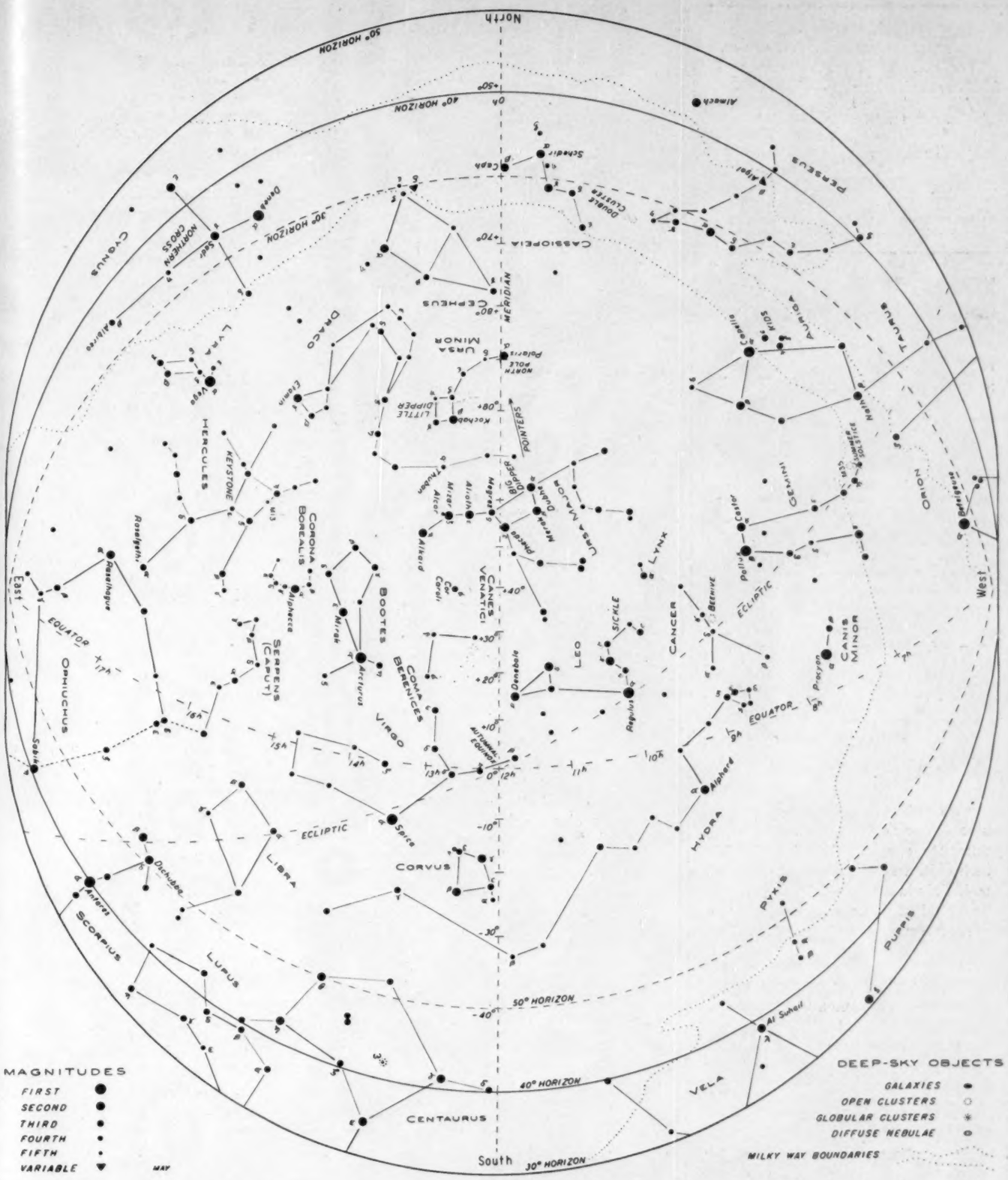

DEEP-SKY WONDERS

JUST SOUTH of the great nebula-strewn areas of Virgo lies Corvus, often called the Sail by navigators. It is easily recognized despite its paucity of stars, and it contains a few nebulae. **NGC 4361**, 65^1, $12^h\ 22^m$, $-17°\ 56'$, a peculiar barred planetary with a visible central star. Webb thought it resolvable. **NGC 4782**, 135^1, $13^h\ 00^m$, $-12°\ 11'$, an extremely faint tiny spiral 0.6′ x 0.6′, magnitude 12.9; use a large instrument.

NGC 4590, M68, in Hydra, $12^h\ 37^m$, $-25°\ 56'$, a small bright globular, 3′ dia., 7.6 total mag.; rather easily resolved. **NGC 3923**, 259^1, $11^h\ 48^m$, $-28°\ 33'$, a spiral within reach of smaller instruments, mag. 11.1, but a diameter of only 1.5′.

Southern observers will find three spirals interesting, all unusually close to the galactic plane and near the great Omega Centauri globular cluster. **NGC 5064**, $12^h\ 16^m$, $-47°\ 39'$, mag. 13, gal. lat. 15°; **NGC 4945**, $12^h\ 2^m.4$, $-49°\ 1'$, mag. 9, 11′ x 2′, gal. lat. 12°; **NGC 4976**, $12^h\ 5^m.9$, $-49°\ 14'$, mag. 11, 2′ x 1′.

WALTER SCOTT HOUSTON

STARS FOR MAY

from latitudes 30° to 50° north, at 9 p.m. and 8 p.m. local time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. For the year 1948, these simplified charts replace our usual white-on-black maps, which may be consulted in issues of prior years when information on deep-sky wonders and less conspicuous constellations is desired.

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OBSERVER'S PAGE

Greenwich civil time is used unless otherwise noted.

SUNSET ECLIPSE IN THE NORTHWEST

TERMINATING in the North Pacific at a point well off the Oregon coast line, at approximately 135° west longitude, 44° north latitude, the annular eclipse of May 8th should present at favorable points in the northwest a partial phase of unusual interest and beauty. At sunset, 45 per cent of the sun's diameter will be covered at Seattle, and 36 per cent at Portland, mid-eclipse occurring in both cases below the horizon. Proportionately lesser obscuration will be seen inland from these points and in northern California, but not south of about 40° latitude on the coast line.

The above is based on material submitted by Lewis Lindsay, 2217 Mission St., San Francisco, Calif., who writes further as follows:

"In two similar eclipses, on December 2, 1937, and November 21, 1938, observations were taken from the high hills of San Francisco in the near vicinity of Twin Peaks. In the latter eclipse not more than one sixth of the sun's surface was covered, but the maximum magnitude of the former was about 25 per cent. Here, using overexposed photographic film to view the sun, even without the aid of binoculars, the semblance of the sun to a flat disk changed to a rounded fullness which gave a three-dimensional effect. In the time schedule of the eclipse as a whole, the view of this phenomenon is relatively transitory and must be caught very close to the actual sunset, when both globes seem to have their maximum sizes. The presence of a light haze tends to soften the solar glare and bring a lighter cast to the dark disk of the moon, enhancing the three-dimensional appearance. For best results, a magnitude of 25 to 30 per cent is most desirable."

The **American Ephemeris** lists maximum obscurations of 59 per cent at Fairbanks, Alaska; 18 per cent at Honolulu; and 66 per cent at Manila, P. I. Of special interest is the fact that the vertex of the moon's shadow cone will be very close to the earth's surface as it sweeps across the Sea of Japan. The computed distance is only five miles in latitude +40° 51′, longitude −132° 47′; near this point it is possible that a total eclipse of very short duration will occur. Generally, however, the central eclipse is annular, with a bright rim of sunlight remaining visible all around the moon at mid-eclipse along the path of the inverted shadow cone.

METEORS IN MAY

The May Aquarids reach maximum from the 2nd to the 6th. Rates of seven per hour may be expected after 2 a.m. (local time), when the radiant rises. Swift meteors are typical of this shower, radiating from near Gamma Aquarii. A waning crescent moon will partially hinder observations. E. O.

VARIABLE STAR MAXIMA

May 5, R Aquilae, 6.3, 190108; 7, R Cancri, 6.8, 081112; 8, S Ursae Majoris, 7.9, 123961; 14, V Coronae Borealis, 7.4, 154639; 26, S Carinae, 5.7, 100661; 28, R Hydrae, 4.6, 132422. June 1, R Normae, 7.2, 152849.

These predictions of variable star maxima are made by Leon Campbell, recorder of the AAVSO, Harvard College Observatory, Cambridge 38, Mass. Serious-minded observers interested in making regular telescopic observations of variable stars may write to Mr. Campbell for further information.

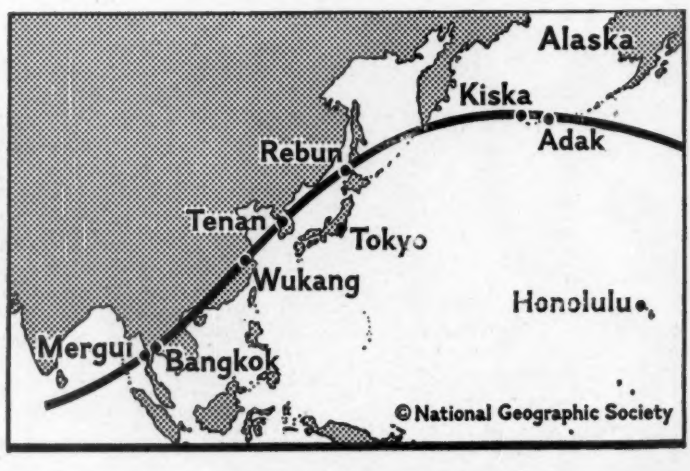
Only stars are included here whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0 Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

PHASES OF THE MOON

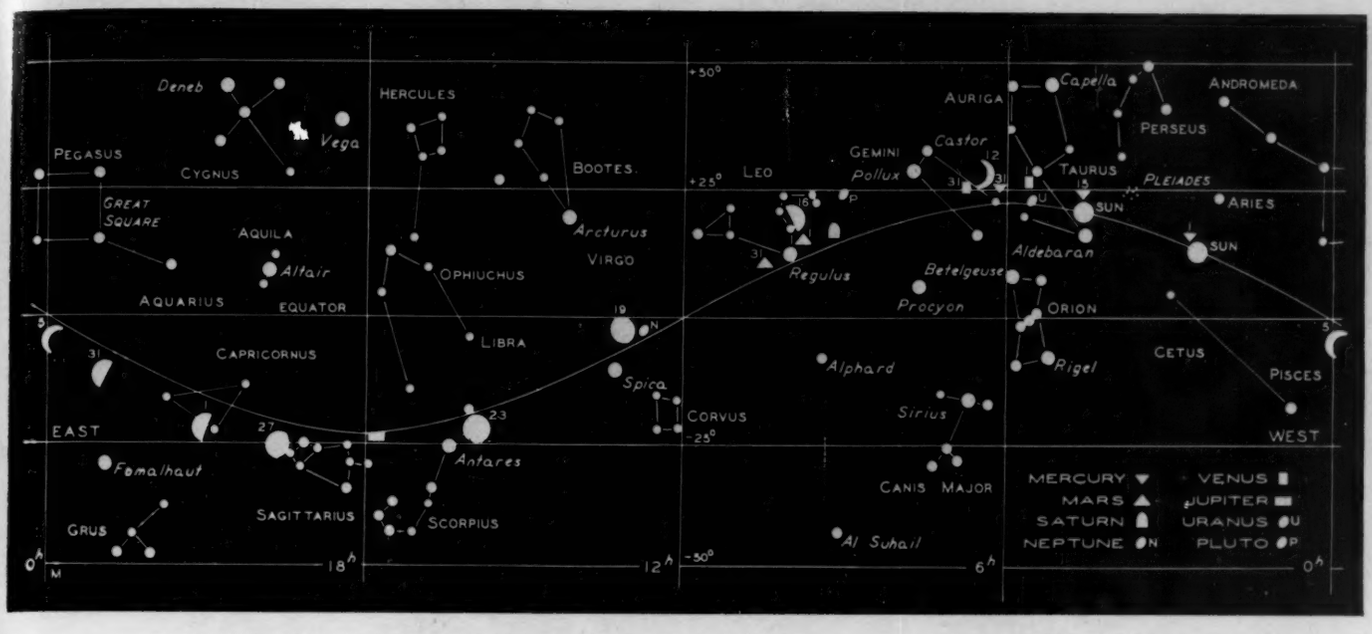
Last quarter	May 1,	4:48
New moon	May 9,	2:30
First quarter	May 16,	0:55
Full moon	May 23,	0:37
Last quarter	May 30,	22:43
New moon	June 7,	12:55

MINIMA OF ALGOL

May 3, 23:23; 6, 20:12; 9, 17:01; 12, 13:50; 15, 10:39; 18, 7:28; 21, 4:17; 24, 1:06; 26, 21:54; 29, 18:43.



Along a 5,320-mile arc expeditions sponsored by the National Geographic Society will observe the annular eclipse at points marked on this chart.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury reaches its most favorable evening elongation of the year on May 29th when it will be 23° 5′ east of the sun. On this date the planet sets almost two hours after the sun, and it will be an easy object to locate during the latter half of May. Under good conditions on May 9-10th, the day after the eclipse, it should be possible to observe Mercury and the one-day-old moon in close conjunction half an hour after sunset; Mercury will be of magnitude −1.1.

Venus attains greatest brilliance on May 18th, although its magnitude during the entire month is substantially −4.2. The planet continues traveling eastward into Gemini. Because of its high declination, more than 27° north, Venus sets four hours after the sun during the first week of May. The last week finds it setting 2½ hours after sunset. The crescent phase may then be easily viewed in a small telescope, as the diameter is over 40″ and the planet is 20 per cent illuminated. See page 109 of the February issue for a diagram of the telescopic appearance of Venus.

Mars may be observed near Regulus during May, about 5° west of the star on the 1st and slightly over the same distance east on the 31st. The third conjunction with the star in six months occurs on May 15-16th, Mars passing 1¼° north.

Jupiter rises a few hours after sunset and is visible the remainder of the night. Jupiter continues its retrograde motion and is in western Sagittarius. All five naked-eye planets will be found above the horizon the last few days of May, 1½ hours after sunset. From west to east they are: Mercury, Venus, Saturn, and Mars, with Jupiter just rising in the east. The three outer planets will be above the horizon as well, in order, Uranus, Pluto, and Neptune.

Saturn, on the meridian on or before sunset, is at eastern quadrature on the 6th, and sets half an hour before Mars. These planets are of nearly equal brightness.

Uranus becomes lost in the evening twilight, as conjunction with the sun occurs next month.

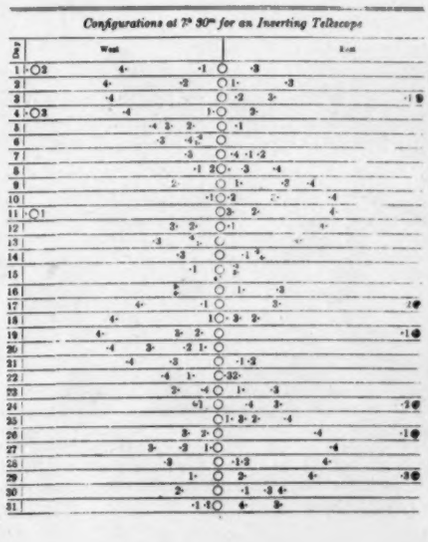
Neptune is in Virgo, 2° southeast of Gamma. On May 11th, Neptune passes about 10′ south of 298 B Virginis (+6.6), the planet a magnitude fainter. (See the chart in the March issue.) E. O.

GREENWICH CIVIL TIME (GCT)

TIMES used on the Observer's Page are Greenwich civil or universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the GCT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the GCT given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. Reproduced from the American Ephemeris and Nautical Almanac.



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COMET BESTER 1947k

At McDonald Observatory a series of direct photographs of Comet Bester 1947k was taken at the prime focus of the 82-inch reflector for purposes of orienting a spectrograph slit along the comet's tail. The prints, submitted by Dr. Thornton L. Page, were prepared by Dr. Page and Dorothy Hinds. The pictures were made on Eastman 33 emulsion, on March 7, 11, 16, and 19, respectively, from left to right. Exposures were two, five, five, and six minutes in the same order, at practically 12:00 universal time in each case.

The comet is following its predicted path very closely. It was observed by David W. Rosebrugh, of Waterbury, Conn., to be of magnitude about 5.2 on March 13th.

OCCULTATION PREDICTIONS

May 13-14 **Omega Cancri** 5.9, 7:57.8 +25-32.2, 5, Im: **C** 1:12.0 −1.9 +0.2 56; **D** 1:10.4 ... ... 41; **E** 0:46.6 −1.8 −0.5 80; **F** 0:46.3 −1.5 −1.8 121.

13-14 **4 Cancri** 6.2, 7:58.6 +25-14.0, 5, Im: **A** 1:28.9 −0.7 −1.4 96; **B** 1:24.2 −0.7 −1.3 91; **C** 1:31.4 −0.6 −1.6 110; **D** 1:22.5 −0.8 −1.5 103; **E** 1:20.1 −0.7 −2.1 129.

15-16 **Eta Leonis** 3.6, 10:04.5 +17-01.0, 7, Im: **H** 4:42.8 −4.1 +1.8 55. Em: **H** 5:08.4 ... ... 10.

18-19 **Gamma Virginis** m 2.9, 12:39.0 −1-09.9, 10, Im: **H** 2:48.3 −2.2 +1.0 89. Em: **H** 3:45.2 −0.4 −2.5 351.

20-21 **Lambda Virginis** 4.6, 14:16.3 −13-08.0, 12, Im: **E** 1:11.1 −2.1 +2.8 67; **F** 0:52.2 −0.6 0.0 118. Em: **E** 1:46.9 +0.6 −2.8 3; **F** 1:58.5 −0.8 −0.6 314.

25-26 **Tau Sagittarii** 3.4, 19:03.7 −27-44.9, 17, Im: **F** 7:27.6 ... ... 24; **H** 6:45.8 −1.7 +2.6 49. Em: **F** 8:05.5 −1.6 −3.5 338; **H** 7:37.2 −0.4 −0.6 323.

For selected occultations visible at standard stations in the United States and Canada under fairly favorable conditions, these predictions give: evening-morning date, star name, magnitude, right ascension in hours and minutes and declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, GCT, **a** and **b** quantities in minutes, position angle; the same data for each standard station westward.

Longitudes and latitudes of standard stations are:

A	+72°.5, +42°.5	**E**	+91°.0, +40°.0
B	+73°.6, +45°.6	**F**	+98°.0, +30°.0
C	+77°.1, +38°.9	**G**	+114°.0, +50°.9
D	+79°.4, +43°.7	**H**	+120°.0, +36°.0
		I	+123°.1, +49°.5

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo** — **LoS**), and multiply **b** by the difference in latitude (**L** — **LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Greenwich civil time to your own standard time.

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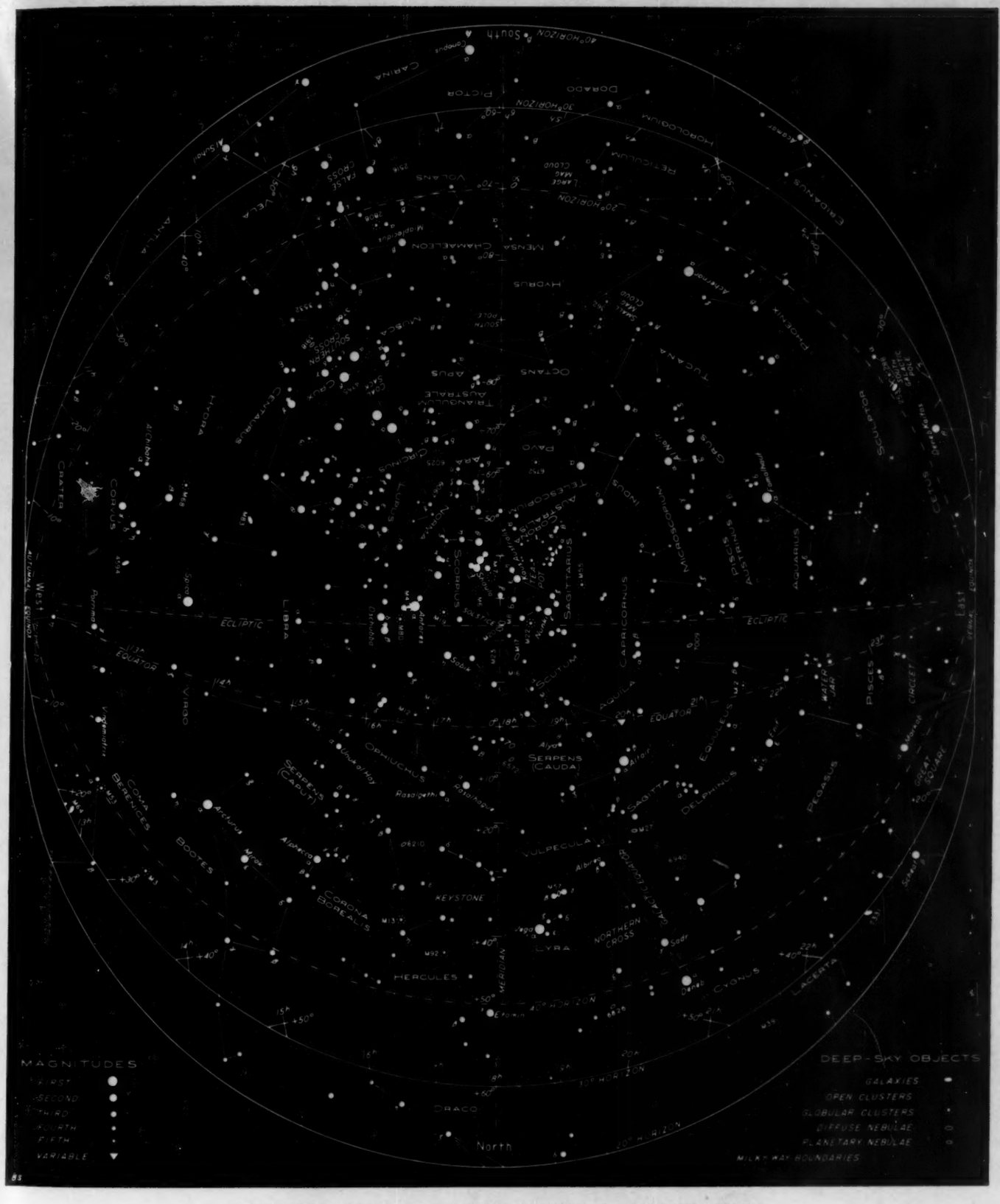

EVENING STARS FOR SOUTHERN OBSERVERS

THIS CHART is prepared for a basic latitude of 30° south, but it may be used conveniently by observers 20 degrees on either side of that parallel. These southern charts appear in alternate months, but always two or three months in advance to allow time for transmission to observers in any part of the world. The sky is here shown as it appears on July 7th at 11 p.m., July 23rd at 10 p.m., August 7th and 23rd at 9 p.m. and 8 p.m., respectively. Times for other days vary similarly, four minutes earlier per day. These are local mean times which must be corrected for standard time differences. The 30° horizon is a solid circle; the other horizons are circles, too, those for 20° and 40° south being dashed in part. When facing south, hold "South" at the bottom, and similarly for other directions. Observers in the tropics may find north circumpolar stars on any of our northern star charts. For other charts in this series, see issues of July, 1946; alternate issues, October, 1946, to August, 1947; and September, 1947, to March, 1948.

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